# Consultation on irrigation in Africa

FAO IRRIGATION AND DRAINAGE PAPER

42

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

# Consultation on irrigation in Africa

Proceedings of the Consultation
on Irrigation in Africa
Lomé, Togo
21-25 April 1986

Sponsored by
the Government of Togo
and
the Food and Agriculture Organization
of the United Nations

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AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS
Rome, 1987

M-56
ISBN 92-5-102547-9

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## 1. THE CONSULTATION

### 1.1 Background

The Consultation arose from a recommendation made by the 13th FAO Regional Conference for Africa, held in Harare, Zimbabwe, in July 1984. The Conference, meeting during a period of acute food crisis resulting from prolonged drought, was keenly aware of the potential that irrigation could offer in increasing and stabilizing agricultural production, reducing the adverse effects of drought, and promoting rural development. It considered that there was a need to examine the irrigation experience on the Continent with a view to incorporating the lessons learned in strategies for future irrigation development. The Conference also felt that there was a need for more exchange of information, discussion and cooperation on irrigation within the African region. It therefore suggested that FAO organize a Consultation on Irrigation in Africa to discuss these issues.

### 1.2 Objectives

The Consultation was to provide an opportunity for senior officials of the governments of FAO Member Nations on the African Continent and representatives of international and donor agencies to exchange views on three principal issues:

- **The present and future role of irrigation in food production in Africa**

  The present irrigated area is rather small. However, inventories of land and water resources show a great potential for expansion. An analysis is needed of criteria and conditions governing the successful development of this potential.

- **Policy options and strategies to attain irrigation development objectives**

  A review must be made of experience gained in irrigation development throughout the region and an analysis of factors contributing to or limiting success. This will provide the basis for the formulation of policies and strategies in the various subregions.

- **Follow-up action**

  National action programmes must provide the tools for the formulation and implementation of country-specific strategies and irrigation development plans. External support needs are to be identified and support mobilized.

### 1.3 Documentation

The FAO Consultation secretariat prepared a series of working documents covering the following topics:

- the state of irrigation - facts and figures
- water resources and irrigation potential in Africa
- economics of irrigation development
- need and justification of irrigation development
- experience gained with irrigation in Africa
- irrigation development in Southeast Asia
- policy issues in irrigation development

Other working documents covered a number of special issues:

- manpower and training needs for irrigation
- women in irrigated agriculture
- the role of non-governmental organizations in small-scale irrigation
- disease considerations in water development for agriculture
- land tenure and irrigation development.

The documents provided information on irrigation conditions, an analysis of experience gained, and an overview of the wide-ranging considerations that govern irrigation development. All this was based on information provided, and views expressed, by technical experts and administrators from various countries and institutions involved in agricultural and irrigation development in Africa, including twenty-five African specialists who participated in four preparatory meetings held at FAO Headquarters in 1985. The first of these focussed on francophone West Africa and took place from 6 to 10 May, the next discussed irrigation development in anglophone Mediterranean, eastern and southern African countries from 24 to 28 June, and the third meeting, for Maghreb countries, was held from 8 to 12 July. Drafts of the Working Documents on experience gained and policy issues were subsequently reviewed by a Panel of six African irrigation administrators and policy makers from 17 to 20 September.

### I.4 Official Arrangements

The Consultation was organized by FAO, hosted by the Government of Togo, and took place in Lomé from 21 to 25 April 1986. The venue of the meeting was the Hotel 2 Février Sofitel. Simultaneous translation was available for English and French. All sessions were plenary.

The Consultation was formally opened by the Minister of Rural Development, H.E. Mr. Koffi Kadanga Walla and closed by a representative of the Minister of Rural Infrastructure. The technical sessions were conducted by Mr. Y. Abdul Mageed, previously Minister of Irrigation and Hydropower in Sudan and Secretary General of the United Nations Water Conference, Mar del Plata, 1977, who was appointed Independent Chairman. Mr. Boe-Allah Lawson of Togo was appointed Vice-Chairman.

A rapporteur was appointed for each session to advise on, and contribute to the preparation of the report on the session. A Drafting Committee, consisting of the rapporteurs and two additional participants, who together covered the various African subregions, oversaw the formulation of the draft final report that was submitted to the Consultation for adoption.

The Committee was composed of the following participants:

Mr. Amadou Taal (Gambia)
Mr. Bechir Lassoued (Tunisia)
Mr. Randrianarijaona (Madagascar)
Mr. C.M. Osoro (Kenya)
Mr. U. Kawu (Nigeria)
Mr. Arona Fall (Senegal)

### I.5 Attendance

The Consultation was attended by a total of 105 participants and observers, including 77 senior government administrators and policy makers of both irrigation and agriculture departments from 41 African states, and 28 representatives of international organizations, financing institutions, donor countries, intergovernment agencies and non-government organizations. A complete list of participants and observers is given in Annex 2.

### I.6 The Programme

The Programme of the Consultation consisted of an opening session, four technical

sessions and a closing session. Three speakers addressed the meeting during the opening session.

H.E. Mr. Koffi Kadenga Walla, Minister of Rural Development in Togo, noted that irrigation had long been perceived as a key issue in achieving food self-sufficiency in Togo. The effectiveness of actions for development must be judged by various economic, social and cultural factors, together with health and sanitation. The Minister emphasized the need for peace and stability as a pre-requisite for successful development.

Mr. J.A.C. Davies, Assistant Director-General and Regional Representative for Africa of FAO welcomed all on behalf of FAO's Director-General, Mr. Edouard Saouma, and reiterated FAO's concern about agricultural production in Africa and the contribution that irrigation can make to raising present production levels. Mr. Davies, referring to the 13th FAO Regional Conference in Zimbabwe in 1984, and the Lagos Plan of Action, emphasized the need for action at both the national and the international level to resolve Africa's food problems. In the African countries, this would require the establishment of clear national policies for irrigation development and firm political commitment to the implementation of these.

Dr. H.M. Horning, Director of FAO's Land and Water Development Division sketched the background to the Consultation and elaborated on the objectives and programme of the meeting. This was the first Consultation on Irrigation in Africa to which all FAO Member Governments on the Continent had been invited, thus the meeting's deliberations and conclusions will carry considerable weight. The outcome of the Consultation will be brought to the notice of the 14th Regional Conference for Africa which is planned to be held in September 1986.

The programme for the Technical Sessions centered on four main subjects:

- the role of irrigation in agricultural production
- experience gained with irrigation in Africa
- policies for irrigation development
- action needed to achieve development.

Summaries of the various Working Documents for each subject were presented by the Consultation Secretariat and a wide-ranging plenary discussion followed each presentation. The full programme is given in Annex 1.

## I.7 **Acknowledgements**

FAO wishes to express its sincere appreciation to the Government of Togo for hosting this Consultation and for the arrangements made in support of the meeting. It also wishes to extend its warm thanks to all national and international participants and observers for their willingness to come to Lomé and for their high-level contributions to the discussions. A special word of appreciation is due to those specialists and consultants from both African and non-African countries who participated in the preparatory meetings, provided inputs in various ways and - in so doing - contributed so importantly to the formulation of the Working Documents. A list of names is given in Annex 3.

## II. HIGHLIGHTS FROM THE CONSULTATION

FAO's 13th Regional Conference for Africa was held in Harare, Zimbabwe, in July 1984 - a time of drought and acute food shortage in many African countries. The Conference therefore suggested that FAO organize a Consultation on irrigation in Africa to explore the potential that existed for increased irrigation on the continent, and to enable FAO's African member nations, international agencies and donor organizations to exchange ideas on the subject.

This document summarizes some of the information that was prepared for the Consultation and the discussions that occurred during it. It makes no attempt to provide an exhaustive summary but seeks instead to highlight those issues that proved of most

concern. The major conclusions and recommendations of the Consultation are presented separately.

### II.1 African Irrigation: basic facts

Africa has not developed irrigation to the same extent as other developing areas, particularly in Asia. Only a little more than 0.3 percent of the 2817 million hectares covered by FAO's 51 African member nations is currently irrigated. By contrast, India - which has only about one-tenth the surface area of Africa - irrigates nearly five times as much land.

The development of irrigation in Africa has also been very uneven. The 9 million hectares that are currently irrigated amount to about 5 percent of the land in Africa under permanent and temporary crops. In other words, 1 in every 20 of Africa's cropped hectares is irrigated. However, in Egypt 98.6 percent of the cropped area is irrigated.

About one-half of Africa's irrigated area is in Egypt and the Sudan. Two other countries, Madagascar and Nigeria, account for a further 20 percent of the irrigated area.

The type of irrigation development that has occurred is even more uneven. Most of what could be described as 'formally organized' irrigation - typically medium- or large-scale projects - occurs in Egypt and the Sudan. This kind of irrigation covers about two-thirds of the irrigated area. The other one-third is traditional, small-scale irrigation in which simpler technologies are used and where there is often only a partial control of the irrigation water. This form of irrigation is somewhat more widely spread; even so, 81 percent of small-scale irrigation occurs in just five countries.

Cereals are grown on more than half of Africa's irrigated land. The percentage of irrigated area taken up by the different major crops is:

| | | | |
|---|---|---|---|
| cereals | 53 | oil crops and pulses | 7 |
| fodder | 13 | fruit | 6 |
| fibre | 8 | sugarcane | 4 |
| vegetables, including potatoes | 7 | root crops, excluding potatoes | 2 |

However, the contribution that irrigation makes to total production of the major crops is very different. The percentage of the major crop types produced under irrigation is: sugarcane 77, rice 58, other cereals 14, oil crops 9, root crops 3.

The value of irrigation in Africa is easily demonstrated. Although irrigation occupied only 6.5 precent of 124 million hectares of cultivated land in 43 African countries during 1970-80, it provided 20 percent of the value of all the agricultural crops grown in those countries. In other words, irrigation increased the value of agricultural production, per hectare, by more than three times.

### II.2 The Potential for Irrigation

Africa has less surface water and a higher rate of evaporation than most other developing regions, and the flows of most of the main rivers, with the principal exception of the Zaire river, are markedly seasonal. In the drought-prone Sahel, where irrigation could make a dramatic impact, the Senegal and Niger rivers are subject to particularly large seasonal variations. Most of the major rivers would therefore need substantial regulation if they were to supply irrigation water reliably throughout the dry season. Furthermore, only a few of the major rivers - notably the Senegal, Niger and Nile - flow through the Sahel region. These factors limit the potential for irrigation in Africa compared to other regions.

However, between the high rainfall tropical zone of Central Africa, and the arid zones of north and south, lie very large dry sub-humid or semi-arid areas. These contain many small rivers and water courses, often with only seasonal flow. There is considerable potential for small-scale irrigation in this area. In fact, this has been practised

for centuries in favourable areas using traditional irrigation technologies.

Some 10 percent of Africa's land area is underlain by high yielding aquifers but much of this water is deep and it is therefore a costly source of irrigation water. Furthermore, the rate of recharge of these aquifers is often low. Many of Africa's coastal deltas and plains contain sedimentary basins with shallow water reserves and where these reservoirs have been over-exploited, they have become contaminated by intrusions of sea water.

In spite of this, there is still considerable potential for expanding the area of irrigated land in Africa. Exact predictions are difficult because of lack of adequate data on water and soil distribution. The best current estimates are that between 30 and 150 million hectares of African land are suitable for irrigation. This is from 3 to more than 16 times the currently irrigated area. Even so, irrigation is not being expanded as fast now as in the recent past. Although the area under irrigation increased by some 4.5 percent annually during 1965-80, progress since then has been only marginal.

Because of the importance of irrigation to Africa's agricultural production, there is an urgent need to refine assessments of irrigation potential, particularly in the semi-arid areas where irrigation development is likely to be critically important in the future. Unfortunately, recent studies suggest that a major limitation may be that soils suitable for irrigation generally occur in areas where there is in any case sufficient precipitation for rainfed agriculture. This finding is important because one of the attractions of irrigation is the extent to which it can be used to expand the area on which crops are grown.

## II.3 The Need for Irrigation

The need to expand irrigation in Africa arises from the present food and agricultural crisis in Africa which has been developing for several decades. As the FAO study 'African agriculture: the next 25 years' recently reported, there has been a widespread decline in per caput food production in Africa. Because Africa's population is likely to double over the next 25 years, a failure to take the steps needed to halt this deterioration "could lead to a situation in which half of Africa's people would be dependent on food imports and food aid from developed countries ... and to widespread famine, with destabilizing consequences both in and outside Africa".

Such a result is by no means inevitable. African soils can be made productive with good management, and the use of more and improved inputs such as seeds and fertilizer. Other requirements include measures to halt soil erosion and improve fertility, and the adoption of agricultural policies that will provide African farmers with the incentives they need to grow more. Given these changes, it is instructive to consider to what extent Africa's resource base is capable of feeding its future populations, and what role irrigation could play - particularly because so much of Africa's land area is unsuited for rainfed agriculture. In broad terms, some 45 percent of the land area is too dry for rainfed crop production, 8 percent suffers from very variable rainfall conditions and 16 percent is very humid. This leaves 30 percent that is climatically well suited to rainfed production of millet, sorghum and maize, the main staple food grains of the continent. Overall Africa has well over 600 million ha of land that could be developed for crop production, although some is only suitable for tree crops.

With this situation it is estimated that both Africa as a whole, and the sub-Saharan region, have sufficient rainfed land resources to produce food for their estimated peak populations in the future, providing the level of input use is increased. This estimate however includes some major assumptions, namely that all suitable land is cleared and cultivated to food crops and that there is unrestricted movement of surplus food and labour.

A somewhat more realistic picture is obtained through assessment of the potentials of the land resources in individual countries to meet future food needs but again the same assumptions are used. Such an assessment reveals major differences between regions. For example, the results indicate that the land resources of North African countries are

insufficient to produce directly that region's food needs even at high levels of inputs and with reinfed and irrigated production. In this region, the largest nation, Egypt, already uses most of the resources of the Nile, but even so the five nations imported about 15 million tons of cereals and 1.5 million tons of sugar net in 1982. Taken together this is sufficient to provide for nearly half of the present total population. Additional irrigation resources are acanty in the region, but the water already available could be used more efficiently. Even if this is done, however, it seems likely that part of the food needs of the populations of the future will have to be met by purchased imports.

In West Africa, the situation with regard to the ability of the resource base to meet future food needs, is somewhat different. Though there are difficulties now and in the future for individual nations, the region as a whole has substantial resources of both rainfed and irrigable land. However, in view of difference in production potentials and difficult communications, further development of irrigation is likely to be required in individual nations particularly those with a high proportion of semi-arid areas.

Similarly, in East and Central Africa, though several nations are in actual or potential difficulty, the complementarities in the region, including Zaire, are such that there could be surplus rainfed support capacity. If Zaire is excluded, however, difficulties could become apparent unless a significant part of the area is farmed at high input levels. The difficulties arise in Burundi, Ethiopia, Kenya, Rwanda, Somalia and Uganda. The main sources of potential rainfed exportable surpluses, other than Zaire, are Tanzania and Ethiopia, provided parts of the areas of these nations are farmed at the high level of inputs. Irrigation may need to be developed further in the more marginal nations, but of these, only Kenya and Ethiopia have sufficient irrigation water to produce significant additional food.

The Southern African region has potential rainfed surpluses, but there are potential deficits at the intermediate level of inputs in the Comoros, Lesotho and Mauritius now, in Namibia after 2000 and in Botswana and Malawi after 2025. The other nations of the region seem able in the very long-term to produce substantial rainfed surpluses, particularly Angola, Madagascar, Mozambique and Zambia, all of which have in addition important potential irrigation resources. It may be necessary to consider additional irrigation in Botswana, Malawi and Namibia, and it clearly has local advantages in Angola, Madagascar, Zimbabwe and Mozambique.

These assessments are not predictions or recommendations, but are general indications on the need for irrigation when environmental resources for production are compared with the needs of future populations. They are estimates of what is technically possible and do not take account of investment, infrastructure and institutional constraints that limit the speed at which the technical potential may be realized. Such factors are discussed in following sections with the foregoing provided as a basis for thought and further study by nations themselves.

### II.4 The Costs of Irrigation

This technical assessment provides the background to decisions that must be made in individual countries about irrigation development. Many factors have to be considered other than the need to become self-sufficient in food production. One of the most important national goals, particularly in semi-arid areas, is to stabilize agricultural production to eliminate the swings in production that now occur when weather conditions fluctuate widely. In many countries, stabilizing production is one of the most important justifications for irrigation development. Where rainfall is erratic, stable production is needed not only for food security but also because it improves the quality of rural life by providing more jobs, higher incomes, increased trade, improved standards of nutrition and some relief for rural women whose husbands might otherwise be forced to work in distant cities or other countries.

The situation in Africa demands that a narrow view of the economics of irrigation be rejected. In drought-stricken areas, where loss of life from famine can be enormous, economics has little meaning. Even elsewhere, greater weight must be given to the human and social advantages of irrigation, as distinct from its strictly economic benefits. Many

of Africa's large-scale irrigation schemes have been dedicated to the production of specific commodity crops for export. The economics of such schemes have usually been assessed in terms of their foreign exchange implications. There is increasing need to include and quantify other factors in such schemes, such as the value of jobs created and the overall effect on rural development.

Irrigation has often been used to produce high-cost food items, such as fruit and vegetables. However, in many areas irrigation has always been considered too expensive for the production of staple foods other than rice. This view is likely to change, given the food deficits of many African countries, the cost of importing cereal, and the difficulties of distributing it. In one sense, of course, all food crops are also cash crops in that they are produced for sale. As African countries alter pricing policies to provide higher prices, and hence incentives, to African farmers, the economics of irrigated farming of staple food crops will change. At the same time, efforts will be needed to lower the high costs that have been a distinctive feature of many recent African irrigation schemes.

African irrigation has often been more expensive than elsewhere. High apparent capital costs are frequently caused by a lack of rural infrastructure, such as roads and settlements, the costs of which are sometimes added to the irrigation cost, producing an inflated total. In addition: sites are often remote, leading to high transport costs and the need for major storage or flood protection works; low development levels often mean there is a shortage of trained manpower, manufacturers and supplies; government and donor policies, such as high exchange rates, high import duties and tied external funds, often add to the problem; and insufficient knowledge of local conditions leads to overdesign and high safety margins.

If future schemes are to be more viable, costs will have to be reduced and benefits increased. One of the main keys will be measures for ensuring that farmers participate fully in both planning and running irrigation projects. Other important options include the improvement of traditional schemes and the rehabilitation of existing schemes that are in a deteriorating condition. New schemes will have to be better adapted to the physical and social conditions prevailing in the immediate environment, and low-cost technologies will have to be used (and even developed) except for strictly commercial schemes involving high-value products.

### II.5 Improving Policies and Planning

Except in North Africa and the Nile countries, irrigation has been introduced into Africa relatively recently. However, there is a wealth of experience to draw on in assessing progress because projects have been developed to deal with a great variety of situations. One result is that African irrigation has both ardent defenders and severe critics. The former regard irrigation as the principal means of solving the continent's food problems while the latter point out that the large investments that have been made have often produced only modest results.

Some of the events of the past decade or so have stimulated the need for irrigation development while others have had a dampening effect. Population growth, urbanization, and the growing demand for rice and soft wheat have all tended to increase the demand for irrigation; but deteriorating economic conditions and reduction in levels of external aid have delayed it.

Several major irrigation projects in Africa have not met with the success that was expected of them. No far-reaching conclusions should be drawn from this fact in view of the severity of the economic crisis from which Africa has been suffering since the early 1970s. During the past two decades, markets for many of Africa's exports have been declining, and the world prices of many of its commodities have dwindled - in some cases dramatically. Furthermore, levels of external aid to African countries have not increased in line with expectations; recently, they have even begun to decline. The coincidence of all these trends has badly damaged the economies of many African countries, with the inevitable result that many plans and projects have either been postponed or failed. All

this reflects more on Africa's external economic environment than it does on the continent's potential to develop its irrigation successfully.

Irrigation and national development policies

Africa is a diverse continent. Not surprisingly, therefore, no single set of irrigation policies can be devised that is applicable throughout the continent. Problems vary widely from area to area, and individual countries must therefore tailor their own policies to suit their particular requirements.

One of the key lessons that has been learned about planning irrigation is that it is vital to identify the roles that irrigation and rainfed agriculture are intended to play in food production and in national development. For example, irrigation may be intended, as in many arid areas, as the sole form of farming; it may be intended, as in semi-arid areas, to complement rainfed farming; or it may be used to grow new, recently introduced crops in wetter areas. One country might use irrigation for all three purposes in different areas. However, while the first use requires no parallel development of rainfed agriculture, the second two uses do. In the past, rainfed farming has too often been neglected in areas where irrigation has been introduced, even though its role in food production was just as important - if not more so.

Similarly, irrigation may be used specifically to grow a cash crop such as cotton or sugar with the sole objective of improving the national balance of payments. Alternatively, it may be used as an instrument of rural development, designed primarily to provide employment and increase rural incomes.

Thus the precise role that irrigation is to play in food production and national development needs to be clearly identified. Projects can then be planned explicitly to meet these objectives, and other requirements - such as the provision of roads, services, credit and agricultural inputs - can be organized ahead of time. If this is not done, irrigation projects rarely achieve their aims.

Irrigation within a country must also be planned on a national or a watershed basis - not as a series of uncoordinated, individual projects. This is particularly important where watersheds are shared by two or more countries. Here special care is needed to ensure that traditional irrigation practices are given sufficiently high priority, and are not neglected in favour of more expensive and superficially glamorous techniques. Also rates of erosion must be reduced, run-off delayed and infiltration improved so that downstream irrigation can flourish on a long time-scale. Finally, there is a need to investigate the possibilities of large-scale damage from rising groundwater tables, increasing salinization and the drying up of inland deltas, which can have major effects on cattle and fish production.

The importance of planning

Irrigation development programmes are not possible unless appropriate institutions exist to plan and execute them. They therefore require the creation of an institution - often at ministerial level - responsible for planning land and water development and use. This institution can then coordinate the activity of other agencies involved in irrigation development and can also prepare long-term irrigation plans. In Zambia, for example, such a ministry has been able to prepare a National Irrigation Development Plan which identifies an irrigation potential of 250 000 hectares. Plans to develop this potential have been prepared at the provincial level for 3, 5 and 15 year time spans.

Plans such as these need an adequate data base. The first planning requirement is therefore knowledge of the physical, social and manpower resources that are available. Such an inventory is critically important as a planning tool. In the past considerable attention was focussed on inadequacies in the physical resource data base, such as information on soils and their extents, water availability, and salinity. Experience shows that a knowledge of the nature and expectations of the societies to be affected by irrigation development is just as important.

A central body with overall responsibility for irrigation development will have to concern itself with many issues other than planning. Two of the most important will be training and research.

Lack of trained manpower is one of the major constraints to developing African agriculture. One problem is that most of the higher-level planning and technical work in irrigation projects is still given to international consultants. As a result, few countries are acquiring the scale of high-level skills they need to develop their own irrigation plans on a systematic basis. In fact, there is a deficit of trained irrigation staff in most African countries at all levels - and this deficit is growing as devolution of responsibilities increases the number of trained personnel required. The growing use of farmer and community associations, for example, is increasing the need for such management skills. The need for more trained manpower is examined in later paragraphs.

There are requirements for further research in many different areas: for example, how to increase the irrigated yields of a number of staple food crops, how to prevent erosion on the upper catchment areas of watersheds, how to develop village-level schemes that are acceptable to local communities, how to develop cheap materials and technologies for construction work, and how to organize the efficient distribution of the proper seeds, fertilizers and pesticides. Most of these issues, of course, require attention at the national or even regional level. However, others need to be included in individual projects, and should be part of the initial design.

## II.6 Formulating Better Projects

Should irrigation projects be large or small? Is it better to start new schemes or rehabilitate old ones? Questions such as these have no answers, other than that every case must be examined on its own merits. The African experience to date certainly confirms the value of small-scale irrigation and the importance of rehabilitating older schemes that have fallen into disrepair. Such rehabilitation, however, must not be restricted only to physical structures. Management systems are generally just as badly in need of overhaul as irrigation canals, sluice gates and storage reservoirs.

African countries with experience of irrigation warn against the hasty adoption of large-scale irrigation in the absence of adequate resource data bases. Some have found that such circumstances produce poor performance, and it may be better for countries without experience in irrigation to learn initially from small-scale schemes, particularly those that can be easily and cheaply initiated by swamp management and improved drainage. For example, in one drought-affected area the water source for a major scheme failed almost entirely for a period of years, reducing the cropped area to a fraction of that originally planned. Ensuring against such an eventuality, if the resource data base is not adequate, would mean transferring water from one basin to another or storing water on a very large scale. Both measures would be expensive.

Four options may be worth pursuing for countries which already have large-scale schemes: rigorous revision of existing large-scale schemes, possibly with rehabilitation and radical improvements in management; the pursuit of more small-scale schemes; a search for more opportunities for medium-sized or village schemes; and encouragement of farmers to develop their own water resources by manipulating input and producer prices in their favour.

One of the major problems with past irrigation schemes in Africa, particularly large ones, has been that many administrative structures became very cumbersome, slow to respond and extremely complex. Over-staffing was one of the significant causes of high operational costs. As a result, there is now an increasing trend towards devolution, with specific responsibilities being given to smaller institutions that are more easily mobilized and are closer to the actual operations. The private sector is becoming increasingly involved, and more and more use is being made of community and farmer associations.

In the past, irrigation projects were designed to produce mainly export crops or crops for urban populations. As import costs have risen, and export prices declined, it

has become necessary to restrict imports of both food and goods, and to allow urban food prices to find their real levels. Over the past decade or so, irrigation objectives have therefore shifted in many countries, with food production now receiving much higher priority.

Along with these changes has come a relaxation of rules about what crops should be grown on newly irrigated areas; the individual farmer is being given an increasing say in what crops should be grown, except in schemes designed, for example, specifically to boost rice production or to grow cash crops such as sugar and cotton. However, more research is needed in the use of irrigation for the production of staple foods. In particular, new varieties of basic food crops need to be developed that will respond better to irrigated growth than to the varieties currently in use.

The cost of irrigation projects appears unlikely to be reduced quickly or substantially, partly because many African irrigation projects are remotely situated. Many are also burdened with the cost of developing local, rural infrastructure. However, the trend towards greater farmer participation in running irrigation schemes could reduce recurrent costs in the future.

Some of the most important lessons learned from an analysis of past projects are that:

- projects must take more account of socio-cultural traditions and be able to respond flexibly to the changing needs of their users;
- special training and incentives (such as improved prices and increased subsidies) will be needed if farmers are successfully to make the long transition from rainfed to irrigated farming;
- the participation of farmers must be ensured from the planning stage on, if irrigation schemes are to be successful; and
- success will also depend on research and training, credit, supply, marketing and transport networks, industries to manufacture irrigation equipment, and spare parts needed in the schemes - and facilities to service these, and adequate educational and health services.

### II.7 Lessons from South-east Asia

An analysis of the role played by irrigation in four Asian countries - Indonesia, Malaysia, the Philippines and Thailand - confirms the importance of these factors. In all these countries, irrigation has produced substantial benefits though problems have been encountered through lack of funds for construction, operation and maintenance, difficulties in optimizing water use, a lack of participation by farmers, and a lack of incentives and training for those charged with operating and maintaining the schemes. The main lessons learned from these south-east Asian countries are that: farmers should begin to participate in irrigation schemes at the planning stage; the same agency should undertake construction of the project and the organization of farmers' participation as these activities are closely interwoven; sufficient resources must be made available to cover the recurrent costs of the scheme; and where governments have to operate and maintain schemes, irrigation fees should be levied from users to lighten the government's financial burden.

### II.8 Improving Policies in Selected Areas

The Consultation examined five specific aspects of policy in more detail. These were the role of women in irrigated agriculture, manpower and training needs, the role of non-governmental organizations, effects of land tenure systems on irrigation development and disease considerations in developing irrigation.

The role of women in irrigated agriculture

As in other areas of agriculture, irrigation development has over-emphasized the role of men and their contribution to family welfare. This balance needs to be rectified. For example, women contribute as much as two-thirds of all the hours worked in African agriculture, and the introduction of irrigation changes not only the role of women in the production of food and cash crops but may also have implications for animal production and household tasks. Irrigation invariably adds to the labour expected of women if the crops involved are those normally produced by women. Furthermore, for a variety of reasons, including the seasonal migration of men to find work elsewhere, more and more women are in effect heads of households. Some 22 percent of households in sub-Saharan Africa are legally headed by women. In practice, the figure is much higher when women take over the household because the men migrate to work. In one African country, 63 percent of households are in effect headed by women.

It is therefore critical that these women be given proper access to land and water, to equipment and production inputs, to credit and marketing facilities, to water users' associations and to training, research and extension.

No simple universal strategy is available for involving women in irrigated agriculture or for solving the problems that irrigation raises for women. However, future projects should identify the target groups by gender; collect data on the socio-economic organization of farming; assess the likely impact on both men and women, both inside and outside the irrigation scheme; and make specific plans to ensure that both men and women are given the access to land and water, equipment and services that their participation in irrigation development will demand.

Manpower and training needs

Lack of trained manpower is one of the most serious constraints to the development of irrigation in Africa. Of the few African countries that have undertaken systematic manpower studies for irrigation, Nigeria finds that it will need, by the year 2 000, 700 professionals, 2 000 technicians and nearly 7 000 vocational workers. This will require trebling the number of places available at educational institutions for professional level staff, increasing places by 50 percent for technicians and increasing vocational level places nine times. While few other African countries are likely to need to make efforts on this scale, all countries planning to develop their irrigated agriculture will have to increase their provisions for training, some of them very substantially. Because of the lag inevitably involved in training personnel, these plans need to be put into operation very soon.

The role of non-governmental institutions

Non-governmental organizations (NGOs) are playing an increasingly important role in development in Africa. They have proved able to work effectively with local populations at village level, promote self-reliance among producers and mobilize additional funds to those available from hard-pressed governments. Reports from Burkina Faso, Senegal, Mali, Sierra Leone, Kenya, Mali, Tanzania, Niger and Chad all testify to the importance of NGOs in helping develop small-scale irrigation. NGOs draw much of their credibility from the fact that the lightness of their structures allows most of the funds they mobilize - and these are now estimated at about five percent of official development aid - to be chanelled directly to the beneficiaries. NGO irrigation projects, almost by definition, involve farmers and villagers even before the projects are formulated and usually base development on existing traditional technologies.

However, NGOs have encountered a number of difficulties. These include: interference from official bodies; lack of technical expertise, tools and equipment; lack of support from government in providing farmers and villagers with the security of land tenure they need; and a lack of control over marketing and price policies that sometimes tend to undermine the success of their schemes.

Some of these difficulties could be eased in the future if national NGOs developed their schemes within existing development plans, if foreign NGOs worked jointly with

national NGOs rather than launching their own projects, and if governments strove to create an environment more favourable to the success of small-scale irrigation. Multilateral organizations could assist by advising their member governments on how to promote policies that favoured the work of NGOs. They also play a valuable role in mobilizing funds from donors for NGO-operated projects, and then providing the NGOs with the technical expertise and equipment which they often lack.

Land tenure

If farmers are to profit from irrigation, they must have assured rights to their irrigated land, and to the supply of irrigation water. Furthermore, if land, irrigation facilities and labour are all provided by different parties - as is often the case in Africa - these parties need to have a clear understanding about who is responsible for maintaining the system, and how costs and profits are to be shared.

Irrigation schemes controlled by the government normally aim to settle farmers on the irrigated land, giving him or her only a one-year tenure. The government imposes the cropping practices and charges the tenant for irrigation services, sometimes even when these are not properly maintained. These schemes rarely meet their objectives because tenants have no commitment to invest in land improvement, and cannot tailor their farming practices to suit their changing needs.

Where irrigation is developed under customary law, the farmer cannot usually obtain credit as his title to the land is not recognized as a legitimate form of collateral. Where farmers develop their own irrigation systems, they sometimes lose the fruits of their own investment if government develops formal irrigation projects upstream.

There are a number of ways in which the impact of these issues can be lessened. Tenants should be given leases longer than one year, be allowed to transfer their tenancies, should have some say in choice of crops to be grown, and should receive accounts from organizations to which they pay irrigation fees. Settlement schemes are often not appropriate for medium-scale developments which may be better organized as commercial or state farms. Schemes smaller than about 500 hectares are better transferred to farmer ownership as soon as possible because they are rarely economic under government management - but farmers must be given legal rights to their land either in the form of freehold titles or long leases.

Implications for health

The introduction of irrigation may have profound effects on health. On the one hand, irrigation offers a chance to provide populations with good supplies of safe drinking water. Where this opportunity is taken, the incidence of many diseases - such as typhoid, scabies, yaws, dysentery, diarrhoea and gastroenteritis - is often reduced by 50 to 100 percent. Unhappily, because supplying safe drinking water can feature as an additional expense on the irrigation cost sheet, this chance is not taken as often as it might be.

On the other hand, irrigation - which inevitably introduces relatively large bodies of water into an area - can result in an increase in the incidence of numerous water-related diseases. The most serious of these is malaria which still causes more than a million deaths a year, most of them in tropical Africa where more than 200 million people live in areas unprotected by any anti-malarial measures. Control is difficult because of the increasing resistance of the Plasmodia parasite to drugs. Lymphatic filariasis, also transmitted by mosquitoes, is endemic over large parts of Africa and schistosomiasis - transmitted by a water snail - occurs in nearly all African countries. In the past, the development of water resources in Africa has frequently produced substantial increases in the incidence of schistosomiasis. A 1969 water resource development in Nigeria, for example, increased the incidence of schistosomiasis from very low levels to some 45 percent within two years.

Irrigation development therefore requires that active steps be taken to control disease. This means that care must be taken to ensure good water management and the

elimination of hazards such as unnecessary bodies of standing water. Community education, to alert people to the causes of water-related diseases and methods of avoiding them, is essential. And community health facilities must be provided to deal with epidemics and implement preventive programmes.

## III. MAJOR CONCLUSIONS AND RECOMMENDATIONS

The Consultation has brought together those responsible for irrigation in 41 African countries and representatives from major donor agencies, international financing institutions and international organizations to discuss the future development of irrigation on the continent. There appeared to be a large measure of agreement on the major issues raised and on the direction irrigation development should take.

A first approach to African irrigation evolved as participants worked out strategies which will help their countries make the most of their soil and water resources. This approach is based on the recognition that:

- irrigation must play an important role in agricultural production in Africa: it may be the only means to stabilize agricultural production in areas having erratic rainfall, and to save human life in drought-prone areas;

- irrigation should not be developed in isolation but should be part of a wide-ranging area development programme;

- irrigation and rainfed agriculture are complementary activities whose balanced development must be ascertained in national production plans;

- irrigation development can be a suitable instrument to achieve social and socio-political objectives;

- farmers' involvement in all stages of irrigation development and management, and devolution of management responsibilities to farmer-water users' associations are indispensable to achieve successful development.

While discussing common problems, and comparing expectations, achievements and disappointments, the participants agreed on the following:

- raising input levels in rainfed agriculture tends to meet constraints similar to those that apply to irrigation development. They are largely of an economic, social and institutional nature and include inadequacies in market systems, storage facilities, management of prices of agricultural produce, credit services, rural infrastructure, etc. These constraints must be reduced or eliminated to permit increases in agricultural production, whether through irrigation or the development of rainfed agriculture;

- governments should adopt policies which provide appropriate incentives to motivate the irrigation beneficiaries to increase production. Examples in several countries showed that, in the absence of such policies, irrigated plots were not given the attention needed to produce economically;

- irrigation projects should not be appraised on the basis of a narrow economic analysis only. Social parameters should be established and included to arrive at a realistic assessment of the viability of the scheme within the context of the specific community and environment;

- a regional planning approach is preferable to a project by project approach. This requires the preparation of region-wide or national master plans for irrigation development. These, in turn, should be based on firm government policies regarding the long-term role that is to be played by irrigation;

- the establishment of irrigation development policies as well as the planning and implementation of irrigation development schemes require a sound data

base. In many countries the available information on water and land resources, land use and crop production, and on social and economic conditions of the farmers is incomplete. Additional surveys and studies are urgently needed;

- while support to small-scale irrigation schemes should be considerably increased, the development of large-scale schemes should not be excluded. In each watershed the desirable mix of large and small-scale development should be established in relation to prevalent physiograhic features, capacity of government to handle schemes and social and economic conditions;

- rehabilitation of schemes, considered by many to have advantages over the development of new projects, is expected to be successful if it is extended beyond the physical system to include the management structure. Such an institutional rehabilitation should be based on clear perception of the roles of government, farmers and private enterprises in the management of the schemes;

- the national capacity for irrigation development and management, limited in most countries, needs to be increased through i) training of staff at all levels, and of farmers, ii) building or reinforcing appropriate institutions for planning, management, and iii) reinforcing research programmes on problems encountered in development and extension services. All were recommended for priority action by government.

## IV. SUGGESTED ACTION PROGRAMME

Key areas for action which will enable the new concept to be translated into practical programmes were identified and agreed by all participants. These involve:

- improvement of every aspect of the data base;
- formulation of sound national irrigation policies;
- development of the national capacity to undertake project planning, implementation and management;
- increased and improved training at all levels;
- a clearer transfer of both practical and theoretical knowledge; and
- increased research.

Taken under individual headings the participants considered the following action elements to be of particular importance.

### IV.1 Improvement of Data Base

Sound irrigation policies can be formulated only when there is adequate information on land suitable for irrigation and its production capacity, the potentially available surface and groundwater resources, the performance of existing irrigation schemes (including small-scale traditional systems) and factors that contribute to success in the farmers' economic conditions and aspirations. The participants felt that improvement of the data base should specifically include:

- an assessment of land and water resources potential at regional, national and river basin levels;
- the establishment of suitable methodologies for collection and analysis of data, and data banks;
- the establishment or improvement of systems and methodologies for monitoring resources, land use and crop production;
- the compilation of an inventory of types and extent of agricultural water development, and its present and potential contribution to production.

Without this information, no sound irrigation policies can be formulated.

### IV.2 Formulation of National Irrigation Policies

Firm national policies are needed to ensure government commitment to a programme, thereby helping to ensure its continuity and improving its chances of success.

The participants proposed that the following should be given priority in national irrigation policy planning:

- establishment of medium and long-term role of irrigation, based on an assessment of available potential;
- development of suitable criteria for the planning, appraisal and priority ranking of schemes, paying particular attention to the social benefits;
- drawing up policy guidelines to support and promote small-scale and farmer self-help schemes;
- preparation of a national plan for investment in irrigation and land reclamation;
- establishment of policies to promote the profitability of irrigated agriculture, including guidelines for the sharing of investment and recurrent costs by governments and farmers, and providing incentives through attractive product pricing;
- establishment/reinforcement of institutions having responsibility for the implementation of irrigation policies.

### IV.3 Development of Project Planning and Implementation Capacity

Project planning and implementation require staff with a wide variety of skills, including irrigation engineering, agriculture, economics, and social sciences. They also require an adequate institutional set up that permits the systematic collection and dissemination of information, through adequate coordination between all agencies involved. The participants stressed the importance of the following to improve the planning and implementation of projects:

- initiation of programmes for monitoring and evaluating the performance of irrigation schemes, including both formal and small farmer schemes;
- development of criteria for planning and appraisal of irrigation projects, related to the specific economic and social objectives;
- evaluation of the national capacity for planning and development of irrigated agriculture;
- development of staff training programmes geared specifically to the planning, development, operation and maintenance of schemes;
- initiation of measures to improve the flow and exchange of information between all those involved in irrigation development.

### IV.4 Training and Development of Human Resources

Shortage of trained and experienced staff at all levels is a major restriction to irrigation development in most countries. Education and training programmes are needed to increase the capacity of staff to deal with the various managerial and technical issues involved in irrigation development and management.

It was felt that the following should receive priority attention:

- assessment of present and long-term manpower requirements and, subsequently, training needs;
- establishment of a national policy for human resources development, and initiation of training programmes with particular reference to farmers' participation in small-scale schemes;
- establishment or reinforcement of institutions with particular responsibility for farmers' training and agricultural extension work.

### IV.5 Research and Transfer of Knowledge

Research programmes inititated so far have been fairly limited in scope, discontinuous and dispersed. Participants emphasized the need to carry out research into the real problems associated with the planning, development and management of irrigation schemes. They felt that these should not be limited to technical matters but should include social, institutional and economic aspects of irrigation. Priority was given to the following:

- identification of priority areas for research;
- development of methodologies to achieve effective farmers' participation in planning, development, construction and management of both large and small-scale schemes;
- initiation of research into ways to reduce the cost and/or improve the benefits of irrigation schemes;
- research into the impact of irrigation on environmental matters such as crop diseases, human health and farming systems.

# PART II

**WORKING DOCUMENTS**

**PRESENTED**

**AT THE**

**CONSULTATION ON IRRIGATION IN AFRICA**

The considerations presented in the working documents are based on information provided and views expressed by technical experts and administrators from various countries and institutions involved in agricultural and irrigation development in Africa, including twenty-five African specialists who participated in three meetings held in Rome in preparation for the Consultation.

Doc. I-A
(Original in English)

# STATE OF IRRIGATION - FACTS AND FIGURES

SUMMARY

**SUMMARY**

Following background information on the physical and social environment of the Continent, this paper presents some facts and figures on recent irrigation development, the types of irrigation and scheme sizes, the extent and distribution of the present irrigated areas, and the contribution of irrigation to agricultural production.

Surface water is very unevenly distributed. Most African rivers show considerable seasonal variation in flow. It is assumed that 50% of the total water resources is available for irrigation. Groundwater is estimated to comprise some 20% of the total water resources and about 10% of the land is underlain by high yielding aquifers.

The soils show a great variation and range from calcareous desert soils to deeply weathered and acid soils of the humid tropics. In many parts, soils are subjected to various forms of degradation including wind and water erosion and salinization. In spite of these constraints, the soils in Africa can be made very productive with good management.

The population presently reaches about 514 millions, with a density of 17 persons per $km^2$; it is growing at an average rate of 3% per year.

Africa's irrigation types and practices can be classified in various ways, e.g. according to scheme size, degree of water control, level of technolgy or type of management. Small-scale developments often have only partial water control and use traditional methods of water application and local materials. Formal irrigation projects are typically from medium to very large-scale developments and usually managed by a government institution. From 1965 to 1980, the irrigated area expanded at an average rate of 4.5% per year. After 1980 it has grown only marginally.

Of the total land area of FAO's 51 Member Countries, some 9 million hectares are irrigated. This represents 5% of the area under temporary and permanent crops. Over 6 million hectares of these, or about 70%, are located in 4 countries: Egypt, Sudan, Madagascar and Nigeria. Traditional irrigation has long been practised and covers 1/3 of the total irrigated area; of the 2/3 under formal irrigation, most of it lies in Egypt and Sudan.

Excluding fodder crops, the area under irrigation represents about 6.5% of the 124 million hectares of cultivated land but 20% in terms of total production value. Rice and sugarcane are the main crops produced under irrigation and they contribute 58% and 77% respectively to total production. The overall contribution of irrigation to total cereal production is 20% and to oil crops 9%.

* * * * * * * *

## 1. SCOPE; IRRIGATION DEFINED

This paper presents some facts and figures on the present state of irrigation in Africa. These relate primarily to the physical and social environment of the Continent, the prevailing types and extent of irrigation in major regions, and the contribution of irrigation to agricultural production. The paper does not attempt to analyse and evaluate irrigation schemes and achievements of irrigated agriculture, and there is no discussion of institutional arrangements, constraints to irrigation development, cost factors, and related issues. These topics are dealt with in other main documents of the Consultation.

For the purpose of this study, irrigation refers to the application of water supplementary to that supplied directly by precipitation for the production of crops. Application implies some form of water control. This broad definition covers a wide range of conditions which include sophisticated formal irrigation schemes with extensive permanent infrastructural facilities as well as traditional flood recession practices under limited water control systems.

## II. THE DATA BASE

The data used in the compilation of this paper have been obtained from the countries concerned and from various studies made by FAO such as Agriculture Towards 2000 (1981), Potential Population Supporting Capacities of Lands in the Developing World (1982), the FAO Production Yearbook (1983), Agro-Ecological Zones Project (1978), and the In-depth Study on Food and Agricultural Problems in Africa (in preparation), and from World Bank and other UN reports. The data are those available at the time of printing. They are partly incomplete and provisional. Comparison of data from different sources sometimes shows a considerable variation. For example, estimates of the total irrigated area in some countries vary by more than 200%. Some causes of the discrepancies are:

a) Terminology used: variation in interpretation of what is meant by "irrigation", causes differences between figures from the various sources. This is particularly so when reference is made to a specific type of irrigation or category, e.g. "traditional irrigation", without a clear definition of what is included and what is not.

b) Definition of irrigated area: there is a lack of consistency in the use of the term "irrigated area"; it may refer to equipped area, area in use, area actually cropped (whether on average or in a specific year), or area harvested.

c) National statistics: in some countries there is no proper mechanism for routine recording of irrigated areas, while in others such data are compiled by more than one organization which almost invariably leads to differences in figures.

d) Area actually irrigated: this varies from year to year in some countries.

In countries in which irrigation is, or is likely to become, an important input to agricultural production, it is essential that an adequate data base be established. Irrigation planning must be based on detailed information on the extent, type, location and state of all existing irrigation, as well as on an accurate assessment of the available potential. (For social, economic, institutional and associated data requirements reference is made to other Consultation documents, particularly Doc.II-A and Doc.III-A).

## III. THE PHYSICAL AND SOCIAL ENVIRONMENT

The African Continent includes 51 FAO Member Countries, covering a total area of 2817 million hectares of which some 9 million hectares (0.32%) are irrigated. Over 6 million of these, or about 70%, are located in four countries:

| | |
|---|---|
| Egypt | 2.76 million ha |
| Sudan | 1.75 million ha |
| Madagascar | 0.96 million ha |
| Nigeria | 0.85 million ha |
| Total | 6.32 million ha |

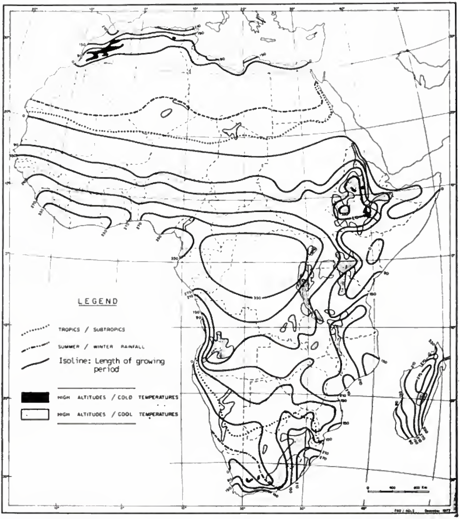
Just over half of the Continent is too dry for reliable rainfed agriculture.

### III.1 Major Climatic Zones

The climatic factors that affect agricultural production most are temperature and rainfall. Their combined effect on crop growth can be expressed in the length of the growing period. The growing period is the period (in days) during a year when rainfall exceeds half the potential evapotranspiration, plus a period required to evapotranspire an assumed 100 mm of water from excess rainfall (or less if not available) stored in the soil profile. Figure 1 shows a generalized climatic inventory for Africa indicating the isolines for the following lengths of growing period: 0, 90, 150, 210, 270 and 330 days.

FIGURE 1

GENERALIZED CLIMATIC INVENTORY - AFRICA
MAJOR CLIMATIC DIVISIONS AND LENGTHS OF GROWING PERIOD ZONES



The major climatic zones, as indicated by the isolines, and their relative importance are shown in Table 1:

Table 1: Climatic zones

| Climatic Zone | Length of Growing Period (days) | Approx. Rainfall (mm/year) | Moisture Availability | % of total land area |
|---|---|---|---|---|
| Desert | 0 | 100 | deficit | 29 |
| Arid | 1- 74 | 100-400 | deficit | 17 |
| Semi-arid | 75-119 | 400-600 | deficit | 8 |
| Dry sub-humid | 120-179 | 600-1200 | adequate | 10 |
| Moist sub-humid | 180-269 | 1200-1500 | adequate | 20 |
| Humid | 270-365 | 1500 | excess | 16 |
| TOTAL | | | | 100 |

It appears that:

- 46% of the continent is unsuited to direct rainfed crop production, i.e. lengths of growing period 0 and 1-74 days;
- 8% suffers from very variable moisture conditions, i.e. the 75-119 days growing period zone;
- 16% suffers from moisture excess, i.e. the more than 269 days growiog period zooe;
- only 30% of the continent, i.e. the 120-179 days zone and the 180-269 days growing period zone, is well suited climatically to the rainfed production of millet, sorghum and maize, the staple food crops.

### III.2 Major Regions

Africa's land resources vary widely, even within countries. For the purpose of this paper Africa has been subdivided into 6 major regions, with each region having broadly distinctive environmental features (Table 2), which may be summarized as follows:

**Mediterranean and arid North Africa**:

No humid areas; 7% climatically suited to rainfed temperate crop production along the Mediterranean coast; 93% of the region is desert and arid.

**Sudano-Sahelian Africa**:

Predominantly desert and arid areas (32% and 36% respectively). Potential for tropical rainfed annual crops in the moist sub-humid (7%) and in the dry sub-humid areas (15%); the latter zone and the semi-arid areas (10%) offer potential for extensive grazing.

**Humid and sub-humid West Africa**:

Dominated by moist sub-humid (47%) and humid conditions (35%). Suited for a wide raoge of annual and perennial tropical crops. Small areas with dry sub-humid (15%) and semi-arid conditions (3%).

**Humid Central Africa:**

Dominated by humid (69%) and moist sub-humid (29%) conditions, suited for a limited number of annual and a wide range of perennial tropical crops. Extensive areas under forest; small areas of dry sub-humid conditions (2%).

**Sub-humid and Mountain East Africa:**

This region encompasses the widest variety of environmental conditions, ranging from desert in the eastern lowlands to humid areas in the cool highlands. Desert, arid and semi-arid conditions prevail in the larger part of the area (48%). More favourable conditions occur in the dry sub-humid (11%), moist sub-humid (27%) and humid (14%) areas. The land in this region is put to a wide range of uses with potential for annual and perennial, temperate and tropical crop production and grazing in the semi-arid parts of the region.

**Sub-humid and semi-arid Southern Africa:**

Large extents of desert and arid (22%) and semi arid (16%) conditions. More favourable environments in the dry sub-humid (19%), moist sub-humid (40%) and humid (3%) parts of the region. Potential for grazing and annual, mainly tropical but some temperate, crop production.

Table 2: Climatic zones in the major regions (percentages of the total area of each region)

| Region | Climatic zones | | | | | |
|---|---|---|---|---|---|---|
| | Desert | Arid | Semi arid | Dry sub-humid | Moist sub-humid | Humid |
| Mediterranean and arid North Africa | 86 | 7 | 3 | 2 | 2 | 0 |
| Sudano-Sahelian Africa | 32 | 36 | 10 | 15 | 7 | 0 |
| Humid and sub-humid West Africa | 0 | 0 | 3 | 15 | 47 | 35 |
| Humid Central Africa | 0 | 0 | 0 | 2 | 29 | 69 |
| Sub-humid and mountain East Africa | 10 | 25 | 13 | 11 | 27 | 13 |
| Sub-humid and semi-arid Southern Africa | 7 | 15 | 16 | 19 | 40 | 3 |
| TOTAL % by zone | 29 | 17 | 8 | 11 | 21 | 14 |

The countries in each region and their surface area are presented in Table 3 and Figure 2.

Table 3: Countries in major regions and land areas

| Region No. | Region | Countries | land area* (million ha) | % of total land area |
|---|---|---|---|---|
| 1 | Mediterranean and arid North Africa | Algeria, Egypt, Libya, Morocco, Tunisia | 574 | 20 |
| 2 | Sudano-Sahelian Africa | Burkina Faso, Cape Verde, Chad, Djibouti, Gambia, Mali, Mauretania, Niger, Senegal, Somalia, Sudan | 828 | 30 |
| 3 | Humid and sub-humid West Africa | Benin, Ghana, Guinea, Guinea-Bissau, Côte d'Ivoire, Liberia, Nigeria, Sierra Leone, Togo | 207 | 7 |
| 4 | Humid Central Africa | Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, São Tome and Principe, Zaire | 399 | 14 |
| 5 | Sub-humid and mountainous East Africa | Burundi, Comoros, Ethiopia, Kenya, Madagascar, Mauritius, Rwanda, Seychelles, Uganda | 250 | 9 |
| 6 | Sub-humid and semi-arid Southern Africa | Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia, Zimbabwe | 559 | 20 |
| | TOTAL | | 2 817 | 100 |

* refers to the total land area of the 51 FAO Member Countries.

### III.3 Surface Water Resources

In general, Africa has less surface water and higher evaporation per unit area than other regions of the world. Most African rivers show considerable seasonal variation in flow, a notable exception being the Zaire River. To facilitate irrigation, some rivers would require major regulation works as at present they are not able to meet the irrigation water requirements in the dry season. Africa's surface water is very unevenly distributed. The Zaire basin, which occupies some 16% of the surface of sub-Saharan Africa, has 55% of the mean annual water discharge. Only a few major rivers - most notably the Senegal, Niger and Nile - flow through the substantial drought-prone areas of the Sudano-Sahelian region, where there are severe climatic restrictions on rainfed agriculture.

The portion of rainfall running off overland and forming river courses varies considerably. In the Sahara region and in the Horn of Africa, there is practically no runoff and there are no surface water resources. In the Sudano-Sahelian region extending from Senegal to Somalia, runoff is, on average, up to 10% of the rainfall. In the wet tropical highlands of Ethiopia, runoff is currently more than 20% of the rainfall. In general, it is assumed that 50% of total surface water resources are available for irrigation.

FIGURE 2

MAJOR REGIONS OF AFRICA


Reproduced from Africa South of the Sahara, with the agreement of Europa Publications Ltd, London

The major African river basins, their area and discharge, are given in Table 4; Figure 3 shows the location of Africa's major rivers and lakes.

Table 4: Major African river basins

| Basin | Major countries | Basin area ($km^2$) | Mean annual discharge ($km^3$) |
|---|---|---|---|
| Zaire | Congo, Zaire, | 4 000 000 | 1 325 |
| Niger | Guinea, Mali, Niger, Nigeria | 1 215 000 | 180 |
| Ogooue | Gabon | 203 500 | 149 |
| Zambezi | Angola, Mozambique, Zambia | 1 250 000 | 103 |
| Nile | Egypt, Ethiopia, Sudan, Uganda | 2 800 000 | 84 |
| Sanaga | Cameroon | 131 500 | 65 |

Between the high rainfall tropics of Central Africa and the arid zones north and south lie very large dry sub-humid or semi-arid areas which contain small rivers and water courses, many of them with seasonal flow only. These hold considerable potential for small-scale irrigation which has in fact already been practised in favourable localities under "traditional" methods for centuries.

### III.4 Groundwater Resources

Groundwater is estimated to comprise some 20% of the total water resources of Africa and about 10% of the land is underlain by high yielding aquifers. The occurrence of groundwater depends on the local and regional climatic and geological conditions. The amount of water annually infiltrated into underground reservoirs depends largely on the amount and time distribution of rain, and part of this water potential is evaporated at a rate which varies with latitude, altitude and temperature. For areas with rainfall under 250 mm, the amount of infiltration is closely related to rainfall intensity. For rainfall betweeen 250 mm and 1000 mm, potential evapotranspiration is the deciding factor and for rainfall exceeding 1000 mm, a substantial part of rainfall is usually available for infiltration.

The water bearing formations underlying more than half the Continent consist of fractured, altered granitic, metamorphic or volcanic rocks containing small discontinuous aquifers. They have a low recharge rate, sufficient only to meet the relatively minor requirements of people, livestock and irrigated gardens. In the great sedimentary basins in the interior of Africa, groundwater yields from thick and extended geological formations can be important, but the groundwater is often deep and thus costly for irrigation. In the desert of North Africa, these aquifers are often artesian. Their recharge is however uncertain and well yields tend to fall off. Abundant shallow groundwater is most likely to be found along alluvial river beds where runoff infiltration takes place. Many coastal deltas and plains of Africa include sedimentary basins with important and shallow permeable horizons. Where they are over-exploited, these reservoirs have been contaminated by intrusions of sea water.

### III.5 Soils

The soils of Africa show a very great variation. They range from calcareous desert soils to deeply weathered and acid soils of the humid tropics. Dark clay soils and alluvial soils can be very fertile while saline soils and shallow soils are not suitable for agricultural production.

The distribution of ten main soil associations is shown in Figure 4. These associations are meant only to provide a schematic overview. A more precise soils pattern should be used for any planning purpose. Table 5 shows the area occupied by the main associations as well as their percentage of the total land area of the Continent.

**FIGURE 3**

## RIVER AND LAKE BASINS

**FIGURE 4**

MAIN SOIL ASSOCIATIONS

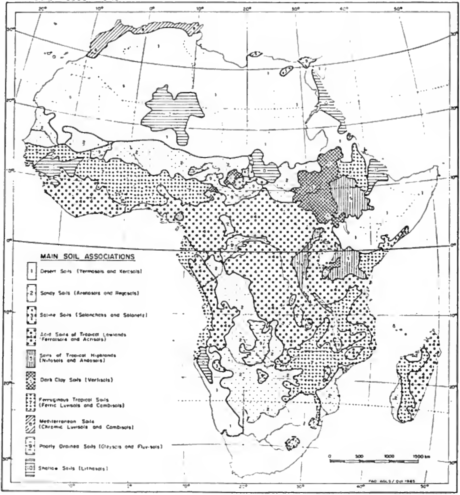


Table 5: Main soil associations of Africa

| Soil associations | Land area (million ha) | % of total land area |
|---|---|---|
| Desert Soils | 620 | 21.8 |
| Sandy Soils | 577 | 20.3 |
| Saline Soils | 67 | 2.3 |
| Acid Soils of Tropical Lowlands | 509 | 17.9 |
| Soils of Tropical Highlands | 39 | 1.4 |
| Dark Clay Soils | 99 | 3.5 |
| Ferruginous Tropical Soils | 194 | 6.8 |
| Mediterranean Soils | 87 | 3.1 |
| Poorly Drained Soils* | 276 | 9.7 |
| Shallow Soils | 376 | 13.2 |
| TOTAL | 2844** | 100.0 |

* The main association "poorly drained soils" includes alluvial soils such as those of the Nile Delta, coastal and river alluvial soils which occur in different regions. These soils are among the more fertile soils in the Continent and would have deserved to be shown separately. However, the scale of the map does not permit this.

** includes Western Sahara

In many parts of Africa soils are subject to various forms of degradation. In the semi-arid and dry sub-humid areas, overgrazing and deforestation for fuel wood has caused severe wind and water erosion hazards. Locally inappropriate landuse has led to desert encroachment. Salinization does occur in areas with deficient water management. The shortening of fallow periods in shifting cultivation, as a result of population pressure, may lead to chemical and physical soil degradation. In spite of these constraints, it should be stressed that soils in Africa can be made to be very productive with good management. On the other hand, it should be realized that at low levels of inputs, soils in Africa have a production potential which is too low to ensure self-sufficiency in a number of countries.

## III.6 Crops

Rice and maize are grown in most parts of Africa. On the savannahs and plains of Eastern and Southern Africa millet and sorghum are important. Root crops, particularly cassava, potatoes, sweet potatoes and yams are grown mainly in humid tropical parts; wheat and barley are grown in Morocco and Sudan and in other eastern and southern African countries wherever climate and altitude are favourable. In addition, pulses, cotton, groundnuts, sesame seed, sugarcane, cashew nuts, sisal, bananas and plantains, coffee, cocoa and tea are grown in various African countries.

## III.7 Population

The population at present reaches about 514 million with Nigeria accounting for around 17% of the total population (Fig. 5). The density is 17 persons/km$^2$ which is low compared to Asia and Europe. Sudan, for example, is two thirds the size of India but its total population is roughly 3% that of India. Zaire is eighty times the size of Belgium but has only three times its population. Overall, the population is at present growing at an average rate of 3 percent per year. The agricultural sector employs 60% to 90% of the population. Africa's nomadic population is important and maintains cattle, sheep, goats and camels moving from one area to another to feed the animals.

FIGURE 5

POPULATION DISTRIBUTION


Adapted from U.S.S.R. *Atlas of Africa* (1968)

## IV. RECENT IRRIGATION DEVELOPMENT

From 1965 to 1975 the irrigated area expanded at an average rate of 4.3% per year and from 1975 to 1980 at 4.8% per year. After 1980, irrigation has expanded only marginally. This expansion however varied widely from country to country.

For climatic and demographic reasons, irrigation development in Africa has concentrated in the north and north-east of the Continent. Water control has been the basis of agricultural development in these countries, and in some the entire economy depends on irrigation. All types of water control for agriculture can be found from enormous storage to small-scale wadi control and water harvesting, from traditional surface irrigation systems to the most modern and sophisticated sprinkler and drip systems. To these can be added projects for the protection of crop land from flooding and the installation of extensive areas of drainage systems for the better utilization of major swamps and river valleys and for the control of salinity in irrigated areas.

In Sahelian and sub-Sahelian Africa, by contrast, water control has played a relatively minor part in agricultural development. This has been limited historically to traditional small-scale irrigation in drought-prone areas, and the reclamation of small swamplands. However, in recent decades there has been a move toward the development of larger schemes, usually for the commercial production of crops such as sugarcane, cotton and rice.

Another important distinction between the zones is that of cropping intensity. While the average for north and north-east Africa is presently about 130 percent, it is only about 110 percent in the other areas. This implies a need to intensify the use of irrigated land in the latter zone in addition to a faster rate of increase in area.

The history of irrigation in Africa, the available resources and the predicted expansion of irrigated agriculture show that future development can be expected to take different directions in the two zones. In north and north-east Africa, the natural resources potential is known to be limited. This means that expansion must take place mostly within the existing infrastructure, as for example in the Nile Valley. The number of possible new developments is likely to be restricted to increased exploitation of groundwater, more intensive production through improved water management, water-saving technologies and higher yields from better drainage. In Sahelian and sub-Sahelian Africa, apart from the great potential for agriculture in the large river basins, there are possibilities for many small developments which can serve to ensure and to stabilize production in areas affected by drought and irregular rainfall.

Traditional irrigation based on simple technology has long been practised in suitable locations and, in general, as population pressure on arable land is not so great in Africa as in other Continents, peasant communities have been based on self-sufficient farming systems adapted to the local environments. Survival has therefore been more important than profit, and risk minimization has taken precedence over surplus production. On the other hand, the objective of recent large-scale formal irrigation in Africa has been commercial crop production using modern technology, supported by efficient management, with adequate physical and social infrastructures, regular supplies of inputs, experienced farmers and efficient marketing.

Both types of irrigation exist side by side in peasant communities and in commercial estates. The growing awareness of:

- the problems associated with rapid transformation of subsistence farming into competitive commercial farming,

- how to approach these problems,

- and the considerable potential for accelerated growth if initiatives are taken by the farmers,

indicates that irrigation development in Africa may be at a turning point.

## V. TYPES OF IRRIGATION AND SCHEME SIZES

The most commonly used irrigation method is surface irrigation (basin, furrow and border irrigation). The schemes obtain water from rivers or reservoirs and use gravity-fed canal systems. Where gravity flow is not possible, water is lifted by pumps. Overhead irrigation (sprinkler and drip irrigation) is used for large-scale sugarcane production and to a limited extent for orchards and vegetables. Flood recession and spate irrigation have been known for a long time in various parts of Africa.

Africa's irrigation types and practices can be classified in various ways, e.g. according to scheme size, degree of water control, level of technology or type of management. One classification method often conflicts with another and overlap between categories exists. For example, both modern irrigation (full water control) and flood recession (little water control) can be found in some large and small schemes.

If the scheme size is taken as the basis for classification, four main categories can be distinguished:

- very large-scale schemes: typically over 10 000 ha with full water control and under government management. Examples are the gravity schemes in the large river basins in Sudan (Gezira), Morocco (Gharb) and Egypt;

- large-scale schemes: typically 1 000 to 10 000 ha with full water control. Generally under government or commercial management, the latter usually less than 5000 hs. Examples are found in Kenya (Bura; Mwea), Tanzania (Mbarali), Somalia (Shebelli);

- medium-scale schemes: typically 100 to 1 000 ha with full or partial water control. government managed, government assisted cooperatives, or commercial estates;

- small-scale schemes: typically 1 to 100 ha, controlled by farmers' groups, or single farmers. Examples are: Kenya, Zimbabwe, Tanzania, Madagascar for simple river diversions, Nigeria (fadama) for shallow groundwater, and Kenya, Tanzania for pumping from lakes.

If the level of technology or the type of management is taken as the basis for classification, the terms "formal" and "traditional" (informal) irrigation could be used. Formal irrigation schemes are usually developed and managed by a government institution on behalf of the smallholders or labourers. Formal irrigation projects are typically medium, large or very large-scale developments. In contrast, traditional irrigation is usually small-scale. It refers primarily to schemes which are under local responsibility, controlled and operated by the community in response to their felt needs. The main traditional irrigation developments include the following:

- small-scale developments using manual or animal power or small pumps to obtain water from dug wells or ponds;

- small temporary river diversions or development of swamps;

- water spreading or harvesting: simple bundings collecting runoff water or flash floods discharging onto flat land.

Small-scale developments often have only partial water control and use traditional methods of water application and local materials. The works may be temporary and may need to be rebuilt annually. In some cases, natural flooding is grouped under the heading of traditional irrigation but for the purpose of this paper it is only considered traditional irrigation if it implies some form of control of water.

## VI. THE EXTENT OF IRRIGATION

### VI.1 Irrigated Areas

Of Africa's total land area, some 25% is considered suitable for rainfed production, 10% is marginally suitable and the remaining 65% is unsuitable.

The distribution of the irrigated area over Africa's major regions is shown in Table 6.

Table 6: Distribution of the irrigated area over the regions

| Region | Irrigated area (1000 ha) | % of total irrigated area in Africa * |
|---|---|---|
| Mediterranean and arid North Africa | 4192 | 47 |
| Sudano-Sahelian Africa | 2242 | 25 |
| Humid & sub-humid West Africa | 937 | 10 |
| Humid Central Africa | 18 | - |
| Sub-humid and mountainous East Africa | 1147 | 13 |
| Sub-humid and semi-arid Southern Africa | 433 | 5 |
| TOTAL | 8969 | 100 |

* Refers to the total irrigated area in 51 FAO Member Countries

The relative importance of irrigation can be expressed, for each of the regions, as a fraction of the regions' land under temporary and permanent crops**. The results are shown in Table 7, and indicate that 5% of the land under temporary and permanent crops is at present irrigated.

Table 7: The relative importance of irrigation, per region

| Region | Irrigated area as % of area under temp. and perm. crops** |
|---|---|
| Mediterranean and arid North Africa | 14.8 |
| Sudano-Sahelian Africa | 7.3 |
| Humid and sub-humid West Africa | 2.1 |
| Humid Central Africa | 0.1 |
| Sub-humid and mountainous East Africa | 4.1 |
| Sub-humid and semi-arid Southern Africa | 1.8 |
| TOTAL | 5.2 |

** This includes land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens, land temporarily fallow or lying idle, land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee and rubber, land under shrubs, fruit trees, nut trees and vines. Excluded is fallow land under shifting cultivation and land under trees grown for wood and timber.

Within the regions a major part of the irrigated areas is found in a few countries only. As Table 8 shows, 50% of the total irrigated area is found in Egypt and Sudan, while the 10 countries with the largest irrigated areas account for 90% of Africa's total irrigated area.

Table 8: Ten countries with the largest irrigated areas

| Country | Irrigated area (1000 ha) | % of total irrigated area in Africa* | cumulative percentage |
|---|---|---|---|
| Egypt | 2760 | 31 | 31 |
| Sudan | 1750 | 19 | 50 |
| Madagascar | 960 | 11 | 61 |
| Nigeria | 850 | 9 | 70 |
| Morocco | 800 | 9 | 79 |
| Algeria | 300 | 3 | 82 |
| Tunisia | 185 | 2 | 84 |
| Mali | 160 | 2 | 86 |
| Tanzania | 154 | 2 | 88 |
| Libya | 147 | 2 | 90 |

* Refers to the total irrigated area in 51 FAO Member Countries

Table 9 shows the relative importance of irrigation for a number of countries. The highest fraction is found in Egypt where virtually all cropped land is irrigated.

Table 9: Relative importance of irrigation, per country

| Country | Irrigated area as % of the country's area under temp. and perm. crops |
|---|---|
| Egypt | 98.6 |
| Madagascar | 32.0 |
| Swaziland | 21.7 |
| Sudan | 14.1 |
| Mauritius | 13.1 |
| Mauretania | 12.0 |
| Gambia | 11.9 |
| Morocco | 9.5 |
| Mali | 7.8 |
| Somalia | 7.2 |

### VI.2 Formal and Traditional Irrigation

The extent of formal and traditional irrigation on a regional basis is given in Table 10 and in Figures 6 and 7. Figure 6 shows the countries with largest areas under formal irrigation. It appears that as much as 46% of Africa's formal irrigation is found in Egypt, while Egypt and Sudan together account for 74%. Figure 7 shows that Madagascar and Nigeria have a considerable share of Africa's area under traditional irrigation.

Table 10: Formal irrigation per region

| Region | Area under formal irrigation (1000 ha) | % of total irrigation of each region |
|---|---|---|
| Mediterranean and arid North Africa | 3410 | 81 |
| Sudano-Sahelian Africa | 1906 | 85 |
| Humid and sub-humid West Africa | 112 | 12 |
| Humid Central Africa | 18 | 100 |
| Sub-humid and mountainous East Africa | 299 | 26 |
| Sub-humid and semi-arid Southern Africa | 301 | 70 |
| TOTAL | 6046 | 67 |

It should be noted, however, that the data provided are provisional only. Not only are the data incomplete for many countries, but there are also differences in the interpretation of the terms formal and traditional irrigation that have an impact (Section II).

## VII. CONTRIBUTION OF IRRIGATION TO AGRICULTURAL PRODUCTION

The total value of the 1979-80 agricultural production on 124 million hectares of cultivated land in 43 countries was US$ 36 851 million (excluding fodder crops). The contribution of irrigation to the total production is given in Table 11.

Table 11: Total area under rainfed and irrigated agriculture (1979-80; 43 countries) and production values (1980; US$; rounded figures)

| | Area (million ha) | % of cultivated area | Production value (million US$) | % of value |
|---|---|---|---|---|
| Rainfed* ** | 116 | 93.5 | 29 376 | 80 |
| Irrigated* | 8 | 6.5 | 7 475 | 20 |
| Total cultivated area | 124 | 100 | 36 851 | 100 |

* including natural flooding
** excluding fodder crops

The area under irrigation represents 6.5 of the total cultivated area but 20% in terms of total production value. Also, the production value of an irrigated hectare is about 3.5 times that of a rainfed hectare.

FIG. 6

Countries' formal irrigation, as a percentage of Africa's total area under formal irrigation

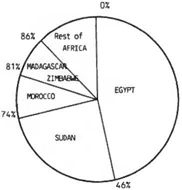
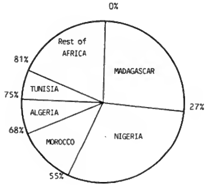



FIG. 7

Countries' traditional irrigation, as a percentage of Africa's total area under traditional irrigation



Cereals (mainly rice, wheat, maize, barley, millet and sorghum) are the major product of Africa's irrigated land, covering over 50% of the total irrigated area (Table 12). The next most important crop is fodder, covering about 13% of the total area; however, nearly 90% of this is in Egypt. The available figures do not include grassland which is an important type of landuse in naturally flooded areas. Fibre crops, covering 8% of total area rank third. Most of this is cotton, and 90% of it is grown in Egypt and Sudan. Vegetables, oil crops, pulses and fruits together constitute about 20% of the total area, though with a heavy concentration of fruit production (37%) in the Magreb countries. The other major staple crops, roots and tubers, are seldom produced under formal irrigation but they do constitute 9% of the area under traditional irrigation.

Table 12: Major irrigated crops

| Crop | Percentage of Africa's irrigated area |
|---|---|
| Cereals | 53% |
| Fodder | 13 |
| Fibre | 8 |
| Vegetables* | 7 |
| Oil crops + pulses | 7 |
| Fruit | 6 |
| Sugarcane | 4 |
| Root crops** | 2 |
| Other | - |
| TOTAL | 100 |

* Including potatoes, grown essentially as an export crop in North Africa
** Excluding potatoes

Table 13 shows the contribution of some important irrigated crops to the total production in the major regions. The importance of irrigation varies widely from one region to another. Rice and sugarcane are the main crops produced under irrigation, and they contribute 58% and 77% respectively to total production. In addition to northern and Sudano-Sahelian Africa, irrigated rice is particularly important in the sub-humid and mountainous eastern part of the Continent (84%). Seven of the major rice producing countries depend for over 90% of their production on irrigation: Egypt, Mali, Niger, Burkina Faso, Gambia, Chad and Mozambique. Overall, irrigated cereals, excluding rice, contribute 14% to Africa's cereals' output. If rice is included this percentage is 20. The second ranking irrigated cereal is wheat with 42% of total production. Irrigated cereals, not counting rice, are particularly important in North Africa.

Table 13: Contribution of irrigation to production in the six regions (1979-80) for 43 countries

| Regions | Rice (paddy) (6) | | | Cereals (7) | | | Sugarcane | | | Root crops | | | Oil crops | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total prod. (1000t) | Irrig. prod. (1000t) | % of total | Total prod. (1000t) | Irrig. prod. (1000t) | % of total | Total prod. (1000t) | Irrig. prod. (1000t) | % of total | Total prod. (1000t) | Irrig. prod. (1000t) | % of total | Total prod. (1000t) | Irrig. prod. (1000t) | % of total |
| Mediterranean and North Africa | 2 406 | 2 406 | 100 | 12 776 | 6 574 | 51 | 9 079 | 9 079 | 100 | 2 511 | 2 443 | 97 | 1 338 | 155 | 27 |
| Sudano-Sahelian Africa(1) | 425 | 276 | 65 | 8 809 | 611 | 7 | 3 667 | 3 667 | 100 | 1 259 | 76 | 6 | 2 567 | 570 | 22 |
| Humid and sub-humid West Africa(2) | 2 749 | 263 | 10 | 10 359 | 24 | 0.2 | 2 873 | 2 390 | 83 | 38 487 | 0 | 0 | 2 947 | 0 | 0 |
| Humid Central Africa (3) | 320 | 35 | 11 | 1 657 | 0 | 0 | 1 727 | 70 | 4 | 17 968 | 0 | 0 | 962 | 0 | 0 |
| Sub-humid and mountainous East Africa(4) | 2 127 | 1 787 | 84 | 9 945 | 0 | 0 | 12 822 | 6 540 | 51 | 12 457 | 0 | 0 | 665 | 0 | 0 |
| Sub-humid and semi-arid Southern Africa(5) | 538 | 159 | 30 | 8 325 | 284 | 3 | 11 854 | 10 607 | 89 | 11 838 | 0 | 0 | 1 559 | 0 | 0 |
| TOTAL | 8 565 | 4 926 | 58 | 51 871 | 7 493 | 14 | 42 022 | 32 353 | 77 | 84 720 | 2 517 | 3 | 10 038 | 925 | 9 |

(1) Excluding Cape Verde and Chad
(2) Excluding Guinea-Bissau
(3) Excluding Equatorial Guinea, São Tomé and Principe
(4) Excluding Comoros and Seychelles
(5) Excluding Namibia
(6) Rough rice
(7) Excluding rice

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(Original in French)

**EXPERIENCE GAINED WITH IRRIGATION IN AFRICA**

SUMMARY

**SUMMARY**

Except largely in northern Africa and in the Nile valley countries, irrigation has been introduced only recently and generally occupies only limited areas. But, because these areas represent a wide range of conditions, they constitute a vast field of experience. Some lessons drawn are given below.

**PLANNING AND ORGANIZATION OF IRRIGATION**

**Sensitiveness of Irrigation to External Factors**

The development of irrigation is closely dependent on a series of factors which are constantly changing, such as the level and nature of food demand, the country's economic situation and the actions of financing agencies.

Such factors as population growth, increase in the rate of urbanization, growing demand for rice and soft wheat, encourage the development of demand for irrigation while others (e.g. deterioration in the country's balance of trade, reduction in external aid) impede it.

**Diversity of Irrigation**

The solutions to be adopted in projects must recognize the diversity of irrigation schemes, particularly as regards the roles of irrigation and rainfed farming in food production, and the main objectives of agro-industrial production or local development:

- Irrigation as the sole form of farming, when no cultivation is possible without irrigation (desert or arid zones). - Irrigation associated with rainfed farming when irrigation makes it possible to intensify crop production or to introduce new crops (semi-arid areas). - Supplementary irrigation of particular crops (humid and semi-humid zones).

Irrigation may be an element in an agro-industrial chain of activities associated with the production of sugar, milk, textile fibres, etc. for domestic consumption or export. It may also be a socio-economically stabilizing factor in a region, where it may help to settle the population, improve its standard of living and satisfy its food requirements.

**Selection of Projects**

It is essential that the selection of projects on a one-by-one basis be replaced by irrigation planning for an entire watershed taking into consideration the different water use needs and their effects on the watershed.

Too many large scale projects have been selected on the sole criteria of availability of water or favourable topography, without taking into account the possibilities for more scattered land development, possibly using traditional techniques (flood-fed crops), and the overall aspects of watershed management (erosion control).

**Organization of Irrigation**

Irrigation may be ineffectively organized for two contrasting reasons: i) inadequate or non-existent Government commitment to irrigation development; and ii) excessive interference by the Government in the operation and management of the irrigated areas.

A change in organization is unlikely to improve the functioning of a large irrigation scheme unless it is based on clear perceptions of the nature of the tasks to be performed. Basically, these tasks relate to overall planning, design and control - administrative tasks for which the Government is responsible - and to implementation, operation and maintenance for which the management organizations are responsible (public

institutions, private companies or users organizations). Problems of coordination of services and decentralization, particularly in the implementation of Government tasks, are widespread and cannot be solved easily.

## IRRIGATION SCHEMES

### Design

Projects do not take sufficient account of socio-cultural institutions and traditions. To remedy this, more use should be made of results already obtained, particularly from pilot projects, and more flexibility allowed during implementation.

Feasibility studies will need to give increased attention to the requirements and traditions of the farmers. They should make the best possible use of experience gained in similar regions, and of pilot projects. Present designs are often rigid and cannot easily be adapted to changing needs.

### Cost

No significant reduction in investments and recurrent costs for irrigation can be anticipated in the immediate future.

Even if infrastructural costs (collective equipment, housing) and the cost of outfitting the farms (sheds, stables), are not included in irrigation cost, the price of irrigation per hectare is often high. The lack of precise data, the donors' desire for guarantees of security, shortage of local enterprises and industries, and long transport distances are some of the underlying reasons which cannot be changed easily.

### Time Overrun

The transition from dry land to irrigated farming can only be achieved through a special training effort and the use of a combination of incentives (prices and subsidies) or possibly coercive measures (obligation to develop the land and to respect crop rotation.

The transition from dry land to irrigated farming entails a radical change in mentality and therefore necessitates a special extension effort with very competent agents, well-adapted economic incentives and, in certain cases, more coercive provisions. There is also a need to remove constraints, to successful irrigation deveopment such as, for example, those related to land tenure, which are found in many countries.

### Management

Farmers participation must be increased if adequate management of irrigated schemes is to be achieved.

Operation and maintenance of irrigation structures is difficult due to, among others, the inadequate price of the water, lack of interest in these repetitive tasks and the absence of maintenance documents. The users are not sufficiently aware of the usefulness of preventive actions, regarding both the networks with which they are concerned and the soil (weeds, salinization, leaching).

## ACCOMPANYING ACTIONS

### Fixing Agricultural Prices

The success of irrigation is closely related to the existence of incentive prices for the production of irrigated agriculture.

The effect of incentive prices on irrigated production is indisputable. But the problems of prices of agricultural products and inputs, including water, subsidies,

taxation and compensatory funds, is complex. The present level of organization of agricultural markets at world level and of regional common markets in Africa render it extremely difficult for the Governments to tackle the problems effectively.

**Agricultural, Economic and Social Infrastructure**

Irrigation development requires an adequate infrastructure: agricultural (research and training), economic (agricultural credit, supply, marketing and transport networks, industries for manufacturing the products necessary for agriculture, processing plants) and social (education and health).

Research is mostly limited to large irrigated areas and industrial crops. It is inadequate with regard to traditional techniques and crops, and to social and institutional problems. Training: some countries do not have specialized training for irrigation engineers. In general there is inadequate training of management and of the future users. Economic infrastructure: many countries have inadequate networks of agricultural credit, supplies and marketing, and this either gives too much weight to middlemen or obliges the development bodies to substitute for these networks and neglect their own tasks. The inadequacy of transport networks results in considerable increases in the cost of the products. Social infrastructure: social infrastructure, particularly with regard to education and health, is a popular requirement. Unless the necessary measures are taken, irrigation can have an unfavourable effect on health by facilitating the development of malaria and schistosomiasis.

* * * * * * * *

## I. INTRODUCTION

Irrigation in Africa has both ardent defenders and severe critics. For the first, irrigation is the main way of resolving the continent's agricultural and food problems. The critics point to the large investments made and the modest results obtained.

2. Except in the North African and Nile countries, irrigation has been introduced only recently and covers only a small part of the total area. But it provides a vast field of experience due to the great variety of conditions. These experiences vary from one country to another and even from one region to another within the same country. Some - by no means the least important - are specific to one country. It will not be possible to deal with these latter in this study. Others concern several countries or vast regions. From these experiences a number of lessons have been singled out which do not claim to cover all irrigation problems but at least those most frequenlty encountered.

## II. PLANNING AND ORGANIZATION OF IRRIGATION

### II.1 Sensitivity of Irrigation to External Factors

**The development of irrigation is closely dependent on a series of factors which are constantly changing, such as the level and nature of food demand, the country's economic situation and the actions of financing agencies.**

Some factors tend to increase the demand for irrigation. The first is population growth, which automatically leads to an increase in the demand for food products. This growth is concentrated essentially in the towns. The farmers no longer have to feed just their own families, but must produce more to supply the towns, in particular through irrigation. Then, too, the change in consumption habits linked to urbanization increases the demand for rice and wheat, which, unlike the traditional cereals (millet and sorghum), require irrigation. Other factors hinder this development, in particular deterioration in trade balances owing to an increase in the price of manufactured products and stagnation of the prices of agricultural exports.

Donors play a complex role. Through the financing provided, they enable new systems to be installed and the irrigated area to be increased. But funding also implies limitations and procedures that may not promote desirable gradual changes. Thus it is sometimes difficult to establish internal rates of return due to uncertainties that exist regarding the rate of development and the choice of crops. The existence of tied aid may hinder standardization of equipment.

## 11.2 **Forms of Irrigation**

**The solutions to be adapted in projects must recognize the diversity of irrigation schemes, particularly as regards the roles of irrigation and rainfed farming in food production, and the main objectives of agro-industrial production or local development.**

It is customary to distinguish between large, medium and small scale schemes government and non-government projects. But there appear to be more important distinctions related to agriculture as a whole and to national development.

Forms of irrigation in agriculture: Bearing in mind the natural conditions, it is possible to distinguish three main types of irrigation:

- irrigation as the sole form of farming: in desert or arid areas irrigation is essential for all agricultural production. The countries concerned usually have a long tradition of irrigation (Egypt, northern Sudan, the Sahara zone), and the problems are those of renovation:

- irrigation associated with farming: in semi-arid areas irrigation makes it possible to intensify existing production or to introduce more productive crops. Irrigated production may be traditional (Fadamas of Nigeria) or recently introduced (Sahelian countries). In many countries, there are old forms of water control (flood spreading, flood recession farming) which, like natural flooding, must be considered a specific type of irrigation (a single watering before sowing);

- supplementary irrigation: in humid and semi-humid countries or regions, irrigation is used only for particular crops (rice, sugar-cane, vegetables, oil palms). With the exception of a few crops grown under specific natural conditions (mangrove rice), these crops have usually been recently introduced.

The various forms of irrigation may co-exist in the same country. Since governments often want to use the same techniques for different farming systems, the priority given to irrigation in arid regions, may lead to a decline in rainfed farming in regions with adequate rainfall. The irrigation schemes then become artificial nuclei in the midst of vast expanses of farmland that are insufficiently developed.

Forms of irrigation in national development: In national development irrigation may constitute an element of activity in an agro-industrial chain (sugar, cotton, dairy-keeping, early vegetables, citrus fruit, etc.), or in the overall social and economic development of a rural zone. These two different functions are not necessarily linked to the size of the irrigated areas, the extent of hydraulic infrastructures nor the type of financing. They reflect an overall concept of management, incorporating the objectives, the means used and the role of the government.

The first has primarily a macro-economic objective, which is usually that of achieving a balance of payment by reducing imports (sugar in Ivory Coast) or increasing exports (cotton in Sudan). It requires considerable water resources, made available through extensive infrastructural facilities (dam inlets or pumping with a high discharge, deep drilling) and is associated with industrial activities for supplying and processing products. In view of the extent of the financial resources mobilized, the means used and the consequences for the economy, this form of irrigation, as an element in a chain of activities, constitutes part of a heavy industrial investment similar, for example, to a steel mill. But, since the final product (the supply of water) is indissociable from its use (agricultural production) it has rather specific characteristics. Therefore the

Government is heavily involved in its organization. Few countries in Africa have the conditions necessary to make this agro-industrial irrigation a driving force in their economy: large water resources; rainfed farming associated with small or medium scale schemes able to provide most of the cereals, fruit and vegetables required; long experience in irrigation; well-functioning irrigation organizations, including competent staff; a sufficiently developed infrastructure for supply and marketing.

The second is essentially an element of local or regional development. Its aims are a high degree of food self-sufficiency, a higher standard of living, more jobs and a settled population. Whenever possible it uses easily mobilizable water resources (perennial river, groundwater), but because of the existing natural conditions such possibilities are rare. Where the resources are not easily available heavy investments need to be made in dams and canals. This form of irrigation can only be incorporated into the socio-economic fabric if a minimum of artisanal and commercial activities exist locally or in the region. The government normally needs to perform only its general role of planning, coordination and assistance. In the zones bordering on the Sahara, as well as in other regions where erratic rainfall precludes a considerable increase in rainfed cereal production, irrigation plays an important role in agricultural development. The main objective for irrigation in these regions is to help increase food production in view of achieving the desired level of self-sufficiency. In practice, however, the present food dependence is often replaced by industrial dependence for the provision of petroleum products, fertilizers and equipment.

It is with irrigation's place in national development in mind that an irrigation scheme should be devised and established. Where this has not been done (e.g. absence of a minimum social and economic infrastructure prior to the establishment of a scheme intended to develop a depressed region), irrigation has been unable to achieve its objectives.

## II.3 Selection of Projects

**It is essential that the selection of projects on a one-by-one basis be replaced by irrigation planning for an entire watershed taking into consideration the different water use needs and their effects on the watershed.**

The selection of irrigation projects has too often been based on a rather incomplete set of criteria: a favourable natural situation, abundant water supplies or a vast zone with regular topography; social or political problems which lead to giving priority to a region; real or supposed preferences on the part of the financing agencies. These projects then mobilize all qualified personnel and enterprises available in the country, to the detriment of other zones. But usually there is no information available on possibilities for scattered irrigation, and it is impossible to develop it because the more competent staff has often been assigned to the implementation of the beacon project.

This frequent absence of irrigation planning within the various river basins is particularly deleterious in the case of international basins. There are, admittedly, agreements between Egypt and Sudan on the use of the waters of the Nile, and organizations which play a coordinating role for certain basins (Senegal, Niger, Chad, Zambezi). But it remains a priority to make a great effort to plan and improve knowledge.

Even when irrigation is planned for an entire watershed, some aspects are often neglected. First there are the traditional irrigation methods that are applied in large areas and are often better adapted to climatic variations than the fixed infrastructure of more recent irrigation schemes (when Lake Chad shrank the recent polders had to be abandoned, but flood-fed farming could continue). Then there are the problems of managing watersheds so as to reduce erosion, delay runoff and improve infiltration. These actions have a favourable effect on irrigation possibilities downstream and are not taken sufficiently into account. The same applies to the recycling of used water (drainage water, waste urban water).

Finally, the possible adverse impact of large irrigation schemes such as a rise of the groundwater table, salinization and the drying up of inland deltas leading to a reduction of the fishing and cattle-raising areas, are not often being studied in sufficient depth.

## II.4 Organization of Irrigation

**Irrigation may be ineffectively organized for two contrasting reasons: (i) inadequate or nonexistent government commitment to irrigation development, and (ii) excessive interference by the government in the operation and management of the irrigated areas.**

Irrigation failures are usually explained by poor organization. But a change in organization does not resolve much unless there is a clear perception of the nature of irrigation and tasks to be performed. Thus, because of their size, schemes along the Senegal and the Niger rivers, which were in fact only groups of medium-sized units, have been managed like agro-industrial schemes. Only recently have those responsible become aware of this and, following the introduction of new concepts, in particular by SAED in Senegal, it is now recognized that each of the units should be managed by the users.

The organization set up does not usually distinguish sufficiently clearly between the various kinds of tasks, which are therefore inadequately implemented:

- overall planning, design and control are administrative tasks for which the government is responsible;

- implementation, operation and maintenance are industrial and commercial - type tasks for which the management organisation is responsible.

<u>Tasks of the Government</u>: Irrigation has only developed in Africa where the Government has been able to play its role of providing guidance and stimulation effectively. These government tasks are usually performed by one or more Ministries or by units of these, according to the importance of irrigation. Two problems frequently arise:

- Inadequate coordination between the Ministries and even between different units of the same Ministry - often the conflicts within a Ministry are as serious as those between Ministries. This problem is of special importance for the coordination between those responsible for irrigation equipment and those responsible for agricultural development, particularly when they do not have any common training in irrigation (civil engineers and agronomists).

- Over-centralization due to shortage of staff makes it impossible to take the different situations into account, and above all, limits Government intervention to large and very specific irrigation schemes.

The management organizations may be public agencies, private companies or users' associations (cooperatives, groups of producers).

When management is entrusted to public agencies there is often confusion between management tasks and government tasks. In addition, such agencies are usually subjected to public accountancy rules (control a priori), and to rules and regulations which apply to the civil service (rigid recruitment and remuneration). They have an almost unlimited field of responsibility (provision of water and inputs, marketing and processing, credit assistance to users, provision of services). The public agencies are plethoric, ineffective and totally isolated from the users and, therefore, they are bound to fail. Recently steps have been taken, at the instigation of the World Bank, to define the tasks and the means of accomplishing them more clearly (contract plan in Senegal, contract programme in Morocco). These tasks comprise: the provision of water against payment, and government services (e.g. extension), charged to the national budget. Maintenance and management of the distribution network at the tertiary level are the responsibility of users.

When management is entrusted to private companies, there will be some negative aspects where the tasks and responsibilities are poorly formulated: part of the "added value' is exported out of the region and even out of the country. Giving management responsibility to private firms may be a pretext for gaining advantages related to importation or distribution, or a monopoly. But it is often an effective solution for an agro-industrial scheme (production of sugar in Zimbabwe).

For small and medium-scale schemes, management is usually entrusted to the users. Unfortunately, there is often no organization to take charge of irrigation management. The Government makes the investment in the scheme, but takes little interest in its operation. Sometimes, if the area concerned is very large, it entrusts management to a public organization. This, however, does not allow the users to participate in the socio-economic development of the region, so that irrigation is seen more as a constraint than as an advantage. Outside the traditional tribal or family structures, farmers have little experience in managing irrigated areas. Various kinds of specialized cooperatives or groups of users are being set up in several countries. Sometimes these are specifically linked to the implementation of irrigation rehabilitation programmes. The Government intervenes only to help set up the necessary structures and train the users in management. Also, sometimes to control disorderly development (e.g. over-use of groundwater, local or temporary over-production). In scattered and isolated irrigated areas of the southern Sahara countries, NGO's may provide the required help. However, their task should be well defined, because enthusiasm does not always make up for lack of technical knowledge.

## III. IRRIGATION SCHEMES

### III.1 Design

**Projects do not take sufficient account of socio-cultural institutions and traditions. To remedy this more nse should be made of reasults already obtained, particularly from pilot projects, and more flexibility allowed during implementation.**

Feasibility studies do not always give sufficient consideration to some technical, or socio-economic aspects, as a result of which project performance may be adversely affected.

- Irrigation feasibility studies normally include crop rotations and methods of irrigation. However, the procedure generally applied is as follows: selection of hydraulic structures on the basis of the physical constraints, selection of crop rotation on the basis of water availability and checking that the family labour force is sufficient to cope with the work. But this labour force has its own exigencies: tending of the rainfed crops - in particular by the women in the regions where they are responsible for food production -, participation in social activities, markets or fairs. The beneficiaries may therefore reject the proposed scheme, even if it is quite satisfactory from an economic point of view.

- Although many examples of irrigation may exist in a region or in neighbouring regions, designers generally resort to standard schemes, which give guarantees of solidity and security. However, these cannot easily be adapted to situations that differ considerbly from the standard one (e.g. insufficient depth of flooding). It is true that the methods of financing do not encourage innovation, which always presents a risk of failure.

- However good the preliminary studies, there are some technical elements on which no complete information can be developed. These include the aptitude of the soils for irrigation and drainage, crop rotations, duration of works, water distribution methods, and human elements (e.g. behaviour vis-a-vis irrigation). This is why the establishment of pilot schemes is common practice, at least where the area to be irrigated is very extensive. Unfortunately, the pilot project is often part the actual irrigation project, while its results should have been used in the feasibility study. The pilot project should in fact constitute the most convincing component of this study (e.g. the Bagre project in Burkina Faso).

- Sometimes, a pilot project is not representative of the overall situation (too small, particular conditions, large staff) and no good use is made of the results. The pilot project, then, will be a waste of time and money.

- The feasibility study usually serves to justify the finaning, and thus becomes a straitjacket from which it is difficult to escape at later stages. Those responsible for the studies undoubtedly consider the maximum number of elementa, but the

impact of these cannot be predicted accurately. And, during implementation, factors may appear that were unknown at the time of the study. These are taken into account when they concern physical aspects such as those related to geology or groundwater, but seldom when it concerns human factors. These latter, though, are as difficult to know as the geological strata or the groundwater.

These problems are worse for countries which are new to irrigation and have few trained staff. They have to turn to foreign consulting firms. If the specifications are poorly prepared their task may not be defined with sufficient precision, participation by local firms may be inadequate, and the field surveys may be superficial. The tight rules imposed by the financing agencies here play a very useful training role, provided that they are eased as soon as the country has been able to acquire the necessary experience and staff.

III.2 **Cost**

**No significant reduction in investments and recurrent costs for irrigation can be anticipated in the immediate future.**

The very high costs per hectare of irrigation is an element of considerable concern. The problem is particularly acute in Africa south of the Sahara. The cost of collective structures, overall infrastructure, housing and collective buildings should not be included in the cost of irrigation works. But even small-scale projects that have few infrastructural elements and that are implemented by the farmers are expensive. The cost remains high, due to a number of factors which cannot be quickly changed:

- sumptuous design of projects, owing partly to the shortage of data and the consultant firm's desire to protect itself against any risks. Even if there is no danger for the inhabitants or for the scheme's water supplies, planners hesitate to plan works that are simpler and less sturdy for fear they may deteriorate too quickly if they are not regularly maintained, and that they will be rejected by the financing agencies;

- shortage of qualified contractors in the country and need to resort to foreign firms;

- need to import most of the supplies (even when some are produced in the country, this may be in a region far away, entailing considerable transport costs).

Attempts have been made to reduce the cost, in particular through implementation of work by the management agency (en regie), and the participation of the farmers. But these measures only reduce the apparent cost, because certain expenses are not taken into account: amortization of equipment used in State-supervised works, additional costs of utilization of structures due to poor execution of the work.

The recurrent costs are also very considerable. In the first place, the loans granted for constructing the irrigation scheme have to be repaid. Usually these loans are reimbursed from the national budget. But some countries require the beneficiaries to participate in the investment. This may comprise the cost of irrigating the actual plot and a certain percentage of the cost of the networks, but always excludes the major structures for water and storage (dams). Operation, maintenance and replacements, together with implementation, necessitate the use of imported supplies, fuel and spare parts, the high cost of which is further increased by transport and storage charges. Those responsible for irrigation usually hope that these costs will be covered by the price of the water. But, for various reasons, e.g. to encourage the users to develop irrigation, to make up for inadequate producer prices, or because recovery services do not have sufficient means, this price often remains too low and is only partially collected.

III.3 **Time Overrun**

**The transition from dry land to irrigated farming can only be achieved through a special training effort and the use of a combination of incentives (prices and subsidies),**

**or possibly coercive measures (obligation to develop the land and to respect crop rotatioo).**

It requires a considerable period of time to reach an acceptable level of development. The frequent failure of irrigation to achieve the results that could reasonably be expected is mostly due to inadequate extension work. The transition from rainfed to irrigated farming entails a complete change in mentality. The objective of food security for the family has to be replaced by the objective of agricultural income, implying investments and monetary risk. Similarly, cattle raisers have to abandon a kind of nomadic system and initiate a sedentary production system. This task is often entrusted to young staff, who may not speak the language of the farmers, have little or no agricultural experience and are only able to transmit instructions. That is why these methods have usually been a failure. In some countries the services reponsible for irrigation have no contact at the farmer's level and the services responsible for agriculture are concerned only with the agricultural aspects, so that there is no extension work on irrigation for the farmers. Solutions have been adopted to improve these two aspects, such as i) the introduction of agricultural advisers specialized in irrigation and able to answer the problems regarding agronomic matters and the use of water, and ii) the participation of users' associations (e.g. association of citrus fruit growers, or vegetable producers in extension activities.

These extension activities are usually combined with economic incentives: subsidies and free services (agricultural work), indemnities in the event of disaster. These measures do not always have positive effecta. If they are not well adapted, as is often the case, they tend to lead the farmers to expect assistance, instead of encouraging a spirit of initiative. In some cases - for example, if the price of water is too low or is not related to consumption - wasteful habits may develop. Other countries, in particular Morocco, have preferred more coercive measures, such as obliging farmers to develop their land and respect the crop rotation. This policy has only succeeded because it constituted a coherent set of measures with regard to legislation, organization and means. But more often it is met with passive resistance by the farmers and in the absence of political will it is a failure.

Finally, there are cases in which land tenure problems have delayed development by several years. Countries with a long tradition of irrigated farming usually have a well-adapted code, even if some practical problems may sometimes arise in applying it. The situation is different in some countries south of the Sahara: even though the Government is the legal owner of the land, it is essential to have agreement on the customary rights. Very often this situation is neglected and, as a result, development may be slowed down considerably (Gorgol in Mauritania). Very often too, the status of the new assignees remains unclear and they do not know whether permanent tenure will be guaranteed - the best incentive for making a personal effort to develop the land. In some cases there is a redistribution every year, or each time there is a change in the composition of the social group concerned.

### III.4 Management

**Farmers participatioo must be increased if adequate management of irrigation schemes is to be achieved.**

Management of irrigation schemes is undoubtedly the biggest problem in most African countries. Many irrigation projects are carried out under external or national financing, without inputs of the beneficiaries. These beneficiaries often do not agree to pay for the water at its cost price. The irrigation structures deteriorate very rapidly and, when rehabilitated, there is still insufficient participation by the beneficiaries. Various factors contribute to this situation: water is often considered to be a gift from heaven, like air; to encourage farmers to use irrigation water its price has to be reduced; maintenance is a task which gives little satisfaction and always has to be done again; often the managers have not participated in controlling the work and do not have correct execution or maintenance documents. Yet in traditional irrigation each user ensured regular maintenance of his part, and all the users worked to maintain communal structures and to repair serious damage. Maintenance has a cultural character. The changes in local societies and the introduction of new operational procedures for irrigated agriculture

mean that it is no longer possible to ensure the maintenance in the same way, and few efforts are made to make the users aware of the management and maintenance problems. However, changes are occurring in a few countries: water distribution and maintenance is entrusted to the users. But these experiments can only succeed if there is a dependable water supply. The managing agencies have often made considerable investments in setting up workshops and stores for spare parts. The results have rarely corresponded to the investments made: workshops also pose problems of maintenance, and the spare parts are often unsuitable and quickly become obsolete. Everywhere there is a shortage of irrigation overseers, able not only to control distribution of water but also to intervene as soon as a problem arises. Similarly, preventive maintenance of mechanical equipment will prevent excessive wear. These simple measures are rarely practised, because in most cases management agencies do not have a maintenance budget, or have such a limited budget that they have to reserve it for the most urgent operations. They are unable to ensure systematic maintenance.

Other factors may aggravate these maintenance difficulties: the absence of enterprises or suppliers able to intervene at the request of the managers; difficult physical conditions (dust, heat) which greatly reduce the life of equipment (about 40 percent for adequately maintained motor-pump units); and above all the absence of simple equipment that could be repaired locally.

Some improvements, such as electrification of the pumping stations (Senegal River delta), can make maintenance easier. But management is not limited to the hydraulic aspects of the scheme. Provision must also be made for regular management of the soils. Unless the users take care from the very beginning to control weeds (eradication of red rice) and to deal with problems of salinity (control of water application, maintenance of drainage systems), the quality of the soil deteriorates. Unfortunately, such preventive measures are often omitted and few of those responsible for irrigation are aware of these problems.

## IV. ACCOMPANYING ACTIONS

### IV.1 Fixing Agricultural Prices

**The success of irrigation is closely related to the existence of incentive prices for the production of irrigated agriculture.**

Farmers will not start growing an irrigated crop, which requires more effort and money, unless they are certain that there will be benefits in both good and bad years. Thus the production of lowland rice in Ivory Coast soared following a steep increase in the price of rice, and started to drop when the price advantage over other crops decreased.

The problem of agricultural prices is complex and goes well beyond the African countries themselves. Every Government wants to attain four objectives which are not easily compatible with each other and with external constraints:

- to ensure the lowest possible prices for consumers and the highest possible prices for producers;
- to encourage the production of certain commodities by incentive prices, while not moving too far away from international prices;
- to reduce the differences between privileged and deprived regions while not diverging too much from production prices;
- to improve the income of the farmers by increasing their profits and limit subsidies on the products.

The Government, therefore, juggles with prices, subsidies and tax exemptions and possibly sets up compensation funds. But it has to face the constraints of the world economy - increase in industrial prices (considerable impact of variations in the price of energy) and stagnation of agricultural prices which do not reflect the cost of production.

The production of irrigated cereals, which is essential in some countries, is particularly handicapped as compared with the production ensured in other countries without irrigation. This artificial process of price formation is not specific to the African countries, but these countries suffer more from it because national markets are small and efforts to organize them are not very successful. There are further consequences that result from controlled prices: incentive prices may lead to an artificial expansion of production through clandestine imports; the existence of uncontrolled prices side by side with controlled prices may result in a distortion in production.

IV.2 **Agricultural, Economic and Social Infrastructure**

**Irrigation development requires an adequate infrastructure: agricultural (research and training), economic (agricultural credit, supply, marketing and transport networks; industries for manufacturing the products necessary for agriculture, processing plants) and social (education and health).**

Like all types of farming, irrigation has requirements with regard to research, training, development, credit, supplies and marketing. But since it is an intensive form of farming, requirements are usually stricter and more imperative. The effectiveness of the network also depends on the existence of a more general transport infrastructure to permit trading, and an industrial structure to enable the products necessary for agriculture to be produced. Finally, people will only remain in an area if social services of education, health and distribution of drinking water are available.

IV.3 **Research**

There are a few specialized research centres which deal with irrigation techniques, like, for example, in North Africa and West Africa (CIEH), but university research is often unrelated to practical problems. Research is usually limited to major hydraulic problems in irrigation such as:

- with regard to mobilization of resources: the choice between pumping and gravity, and between fixed and floating stations, the use of natural vectors to transport water;
- with regard to distribution of the water: the regulation systems, the choice between distribution on demand and rotational distribution;
- with regard to irrigation of the plot: the use of new methods of irrigation (sprinkle, drip), drainage and reclamation.

But research on small irrigated areas and the use of simple or traditional techniques is limited. Also, there is little research into social and institutional problems despite their importance.

As regards research into land development, the situation is similar. The research centres, often linked to large irrigation schemes, concentrate on the main crops and neglect the traditional crops and the economic, social and organizational aspect at the level of the individual farms: simplified farm accounting, optimum farm size, method of cultivation (manual, animal, mechanical). Similarly, agronomic research takes insufficient interest in the specific aspects of irrigation: use of varieties and techniques suited to irrigation, over-irrigation, salinization of the soil.

IV.4 **Training**

Training concerns, on the one hand, the staff of the administration and the management agencies. In many countries, particularly English-speaking countries, there is no specific training for irrigation engineers. The irrigation schemes are usually carried out by civil engineers who call on agronomists for the specific aspects of land development. But in most cases training in managing these schemes remains very inadequate.

Training also concerns the farmers. Apart from the particular effort to be made at the beginning of the scheme's operation, as mentioned in previous sections, there is usually no long-term action, particularly with regard to farmers' children.

## IV.5 The Economic Infrastructure

If irrigation is to succeed the farmers must have enough funds, supplies must be delivered in time, be sufficient and of good quality, and good marketing conditions must be guaranteed.

- Financing: The farms have often been financed indirectly by the land development companies which had a monopoly of supplies and marketing. The establishment of agricultural credit in many countries makes it possible to improve the situation. But there are still difficulties in guaranteeing prices for small farmers and ensuring that credt is sufficiently available in all regions.

- Supplies and Marketing: In most countries the supply and marketing networks are very inadequate. This often means that the middlemen have great power, particularly in marketing. This is why the land development agencies have had to substitute for these networks in many cases, to the detriment of their main tasks. In addition, supplies are often imported and there are few storage facilities for the irrigated produce. These additional constraints make any forecasting and organization almost impossible. A few countries have been able to develop the production of certain supplies, manufacture fertilizer, assemble tractors and create storage capacities: storage sheds, cold rooms. Few joint actions have been taken by countries belonging to the same region to improve the effectiveness of the large investments required.

- Transport: In many countries in Africa, south of the Sahara, the inadequacy or poor quality of the communications network (roads impassable in the rainy season) constitutes a great handicap. In some cases transport costs double prices, thus preventing locally produced cereals from competing with imports in large towns situated near a port. These transport costs may also make locally-produced fertilizer, for example, more expensive than imported products, if the irrigation scheme is farther away from the factory than from a port.

- Processing: The problem of processing concerns essentially the industrial crops. To increase the added value and create jobs, production must be combined with processing. Processing plants do exist, but their capacity and number may not meet actual needs. In some cases their operation is made difficult by poorly organized links with the producers.

## IV.6 The Social Infrastructure

There is a general need for a minimum education and health infrastructure. It is not possible to retain competent staff and dynamic farmers unless they can be sure that they will be able to provide their families with adequate education and health.

In addition, in some regions where considerable use is made of irrigation, the existence of poorly maintained canals and stagnant water has led to the development of diseases such as malaria and schistosomiasis. Only in a few cases has provision been made from the start of the project to control the risks of infection. These preventive actions have been very effective. However, in spite of such problems, the impact of irrigation has generally been positive: marshy areas have been drained as part of the scheme and, above all, the quality and variety of the diet has often improved.

**Doc. III-A**
(Original in English)

# POLICY ISSUES IN IRRIGATION DEVELOPMENT

**SUMMARY**

In most African countries, with little long-term experience of formal irrigation and in a harsh and uncertain international economic climate, the stated goals of irrigation development have often been unrealistic. Imported inputs and technology have failed to produce the predicted results and a possible solution lies in maximizing the use of suitable and known indigenous resources, skills, technologies, motivation and social structure.

There are many national issues to be debated such as the desirable balance between irrigation and rainfed agriculture; the basis for development planning; suitable crops; the optimum scale and mix of project sizes; the choice of rehabilitation, improvement or new schemes and the selection of institutional options. These introduce many factors which must be considered individually and collectively in deciding how best to expand national capacities for irrigation development and management. Foremost among these factors are those concerned with human resources and skills and the transfer of knowledge and experience to the irrigators and the farming community. Research, training and extension services have a role of major importance in this context.

For any national irrigation plan to succeed, it is essential that the component projects be properly conceived, constructed and managed. This is true for projects of all scales although there are distinct differences in the requirements of different types, some calling for a clearly commercial and strictly disciplined approach whereas others, notably smaller scale community initiatives, may be more in the nature of a complement to traditional agricultural practices. It seems likely that future trends will be towards an increase in such community schemes. Consequently, management tasks will not be so limited to production targets but will call for greater attention to social needs, sustained efficiency of resource use and the creation of further incentives for success and improvement in irrigation. The role of government agencies can be expected to shift towards one of stimulation rather than participation.

An issue of increasing importance in project construction and operations is that of containing costs which, in general, are far higher in Africa than elsewhere. The remoteness of many schemes and absence of initial infrastructure calls for unavoidable initial investment, but this may in some cases be a charge on the community at large rather than on the irrigation project. Opportunities for phased investment in both scheme and infrastructure are often overlooked, as also are potential economies in the building of housing, settlements and the provision of services.

Recurrent costs also merit close scrutiny, especially where there is a tendency to inflate the personnel component of a project. Variable cost reduction is a useful aid to project economy, in its agricultural inputs and production aspects, and may be susceptible to improvement through increased involvement of the private sector in supply and services. In both fixed and recurrent costs, there must be a policy for their recovery which is clearly defined, practicable and politically acceptable.

As a corollary to cost reduction, it is also necessary to attain a higher level of returns through increased product prices and better yields. Apart from the implications for broader national policies toward market and farm prices, the on-scheme measures may include a shift to higher value crops or intensification of production, and an increase in the supply of labour or of capital in the form of credit, and perhaps access to foreign exchange for certain imported inputs. The increase in total returns may also be assisted through the better integration of the scheme with the surrounding area in order to derive benefits from off-site productions and by sustaining the productive capacity of land and other resources of the off-scheme environment.

Factors which are relevant to improved irrigation concern the choice and adaptation of technology, the mix between farmer involvement and government support, suitable prescriptions for management systems and the flexibility to adjust to physical, economic and institutional changes. These factors must also be seen against a variety of circumstances and a range of national and community objectives, which are not necessarily mutually compatible.

Irrigation planning is therefore a complex process calling for attention to many variables in a context which will also change with time, requiring effective monitoring and feedback. No single policy package can be designed to meet the widely diverse irrigation needs of all African countries. But past experience has already identified the principles and practices of irrigation policy formulation and planning, and this knowledge can now be applied at national, provincial and project levels.

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## I. INTRODUCTION

Irrigation goals in Africa have often been characterized by insufficient realism. There are several reasons for this, for example (in most African countries) lack of long-term experience with formal irrigation; shortage of trained staff at all levels - policy, implementation, professional, junior technical - and lack of experience of modern systems by farmers; weak infrastructure; the need to import inputs; and the uncertainties of the international economic scene; and these are discussed in this paper.

The following factors have an important bearing on irrigation policy:

- the global macro-economic system is not only harsh on the weaker nations but also unpredictable;

- this combination of harshness and uncertainty affects the availability and price of imported inputs to developing countries and the foreign exchange earned by exports. While import prices rise, export prices may drop, catching dependent national economies in a double trap;

- reliance on inputs from external sources (capital and material goods such as fuel, machinery) is doubly risky;

- moreover, even with the best advice and goodwill, the imported resources (expatriate skills, development plans, engineering designs, machinery etc.) may not be adaptable to the socio-cultural way of life. Consequently they fail.

Given the constraints which militate against the reliable supply and effective use of imported inputs, it is perhaps surprising that imported technology is still considered by many donors to be the only hope for Africa. The answer may lie at least partially in a reversal of roles; minimizing reliance on imported inputs and maximizing the use of available and known indigenous resources - skills, technologies, motivation and social structure. This approach has the advantages of reducing uncertainties and risks related to the external situation, and of increasing self-sufficiency.

For this model of organic growth, rather than imposed change, two basic requirements must be met. The rate of change of the system must be within the absorptive capacity of the people, and their confidence in the process of change must be maintained by success at each step.

With this background to the need for realism in policy making, some major issues at the national and at the project level will be discussed.

## II. ISSUES AT NATIONAL LEVEL

### II.1 Development through Rainfed or Irrigated Agriculture?

Views about how best to proceed tend to be expressed as stark alternatives. Those favouring irrigation emphasize the rapid expansion of high value crops. Those favouring rainfed development doubt the efficacy of irrigation, stressing the high investment costs and the difficulty of managing the projects. This argument oversimplifies the issues.

If, by "irrigation", wa meen "the managemant of watar for tha enhencement of egricultursl production", than thara is e renge of possibla innovations involving irrigation wstar rathar than a claar-cut "rainfad" varsua "irrigatad" choice. In ona placa, local rainwatar may be reteined, end parheps supplamentad, so as to ansure the edequate yield of a crop otharwise dapendant on uncertain rainfall; in enother eree in an arid anvironment, if a crop is to be grown at ell, totel watar raquirament must be supplied; in e third more humid araa, drainaga of axcass watar mey be criticsl.

In comparison with tha improvement of rainfad agriculture, ell projects involving irrigstion ara likaly to ba mora costly. Thera may, in many countries, be a good cesa for concantrsting limitad resourcas on improving reinfad agricultura if returns per unit of invastment ara likely to be significant, widaly spreed end quick to ba raalizad. But in other countries, aspacially where populetion is tending to axcaad the carrying cepecity of rainfad land, or whera high valua commercial crops ara naadad for axport or import substitution, then one form or another of irrigetion davalopment may ba indicated.

Broadly, tha appropriata level of irrigetion invastment dapands on tha expected incremental costs of and returns from various options. This is by no meens en easy set of calculations and tands to be much more difficult than for rainfad innovetions. Such invastments for lerge schemes, ara characterized by:

- e long laad time batwean axpenditure and racoupment;
- s pettern of costs end returns stratching bayond tha 30 yaars normally counted as significant in project eppraisal;
- environmentel costs which may axtand beyond tha parimeter of the irrigated araa;
- msjor social changas accompanying tha investmant;
- political implications erising from this specific choica of locale and dasign;
- a possibla impsct on broad national stratagies such es food self-sufficiency end belence-of-peyments improvements.

Thus, the rainfad or irrigstad policy question is not an exclusive choice batween thasa two, but, rather, the possibility of e variety of watar control systams.

## II.2 Planning Irrigation Development

Devalopment in African irrigation in tha past was largely thought of and formuleted (typically by expatriata consultants) in tarms of lsrga-scala indapandant projacts. Tha planning problam is wider and mora complex snd since irrigetion requires the development of wstar as well es lend, wster resources plenning needs must be met et netional end locel laval.

Investment in irrigstion construction, often heavy snd complex, tends to be regsrded as a onca end for all investment, ignoring the naad for continuad oparetion, management end maintenance. Changes in tha circumstences in which schames ere designed to operata, for instanca the prices assumed for sale of products and for inputa such as fertilizar, machinary and lsbour, may raault in certsin aspacts of the original dasign becoming inepproprlate. One plsnning option may tharafore ba to dasign irrigation davalopment in a stapwisa procass and aim et simplicity and flaxibility. This is particularly applicable to small-acala or informal irrigation. It givas time for adsptation by all thosa involvad and aasas tha adjustmant to future changas in tachnology and msrkets.

Some countries have adoptad rivar bssina as suitabla plenning and davelopment units. Where well defined rivar basins subdivida the netionsl terrein this hes distinct advantagas, but tha poasible disadventages of waakaning tha cantrsl structure, overlepping and axcassive "ampira building" indicate caution. It is slso importsnt to racogniza the divarsa needs of aactoral intaraats in river basin plsnning. Agriculture, for instence, may ba abla to benefit by phaaad watar devalopment in the form of many small diversion or storage projacts. On tha othar hend, alectric anargy ganaration usually requiras major

initial capital investment in large structures, and other forms of development then become subordinated to the energy sector.

Finally, there is a strong case for altering the planning approach taking much more account of the farming households who are identified as the future beneficiaries. To derive maximum value from irrigation water allocated to them, their needs and wishes must be understood. In this sense, planning should take on a "bottom-up" as well as a "top-down" aspect.

### 11.3 Crops to be Produced under Irrigation

The past emphasis, in irrigation projects, has been on crops for either export or urban consumption. Indeed, in some countries, irrigated agriculture has been labelled "the modern agricultural sector", characterized by high value/high cost output, and incorporating technology and institutions totally unfamiliar to the irrigators. Some schemes were designed with a specific main crop in mind.

The focus of concern is now shifting. With rising import costs and low export prices it is becoming necessary to (i) restrict importation of investment goods, (ii) reduce dependence on overseas supplies of food, and (iii) allow food prices in urban areas to find their true level.

The agricultural sector as a whole is consequently under increasing pressure to be more self reliant and the utilization of existing irrigation and its further development will take place in this context. Among the considerations are:

- high cost export crops like cotton will be justified where export markets remain sufficiently buoyant, production costs can be stabilized or reduced, and incentives to the growers are strong;

- high cost foods such as wheat, rice and sugar will be justified if urban market demand persists and importations are restricted;

- high value/high cost foods like fruit and vegetables may be justified where demand is high and marketing costs are low;

- other food-crops, notably maize, groundnuts and sorghum may justify the use of irrigation water as demand increases and as irrigation packages increase yields still further.

However, a central objective must be the production of a sustained surplus of product so as to cover the costs of irrigation. This has not always been easy in some irrigated areas where agro-ecological constraints (soils, salinity, susceptibility to flooding) may severely limit the choice of cropping. So, new farming systems have to be carefully researched and designed.

### 11.4 Are Large or Small-scale Projects to be Preferred?

Although a classification of size (large, medium, small) is often applied to irrigation schemes, it appears that these descriptions are used not only with reference to area, but also to the type of control. Thus "large" is usually taken to be synonymous with centrally planned or formal, and small with local initiative or informal. The difference between these two types of classification needs to be made clear, and where possible the terms large, medium and small used as descriptions of area only, and formal/informal used to describe the type of control or management.

The debate over "large" versus "small" irrigation schemes will be found to relate just as closely to management and control as to size. In most countries of Africa there has not been a long history of large scale formal irrigation (Egypt and the Sudan are exceptions) and its introduction in recent years has met with many disappointments. Evaluation of these experiences shows that the causes of failure are not so much a function of size as of lack of appreciation of the socio-economics of the indigenous peasant farm

ing systems. Where survival comes first, risk avoidance takes precedence over cash crop production in the peasant's view.

In most cases large schemes have been formally planned and are typically managed by government departments or parastatal organizations delegated with the necessary authority for fairly comprehensive control. Most small-scale irrigation, however, has arisen indigenously (or "informally"), is under local responsibility, and is controlled and operated by the local people in response to their felt needs. The development process and policy options available to government are strongly affected by this bipolarity. The question to be answered is whether observed trends imply that some change in balance between large and small-scale projects is desirable.

It must be appreciated that countries differ greatly as to where they draw the line between "large" and "small". Where irrigation is already well developed, a 10 000 ha scheme may be viewed as a small project. This may exceed the entire formal irrigation subsector in other countries.

Large-scale formal schemes are accepted by many policy makers as being efficient and "modern", and hence meriting continued investment. Such projects, can, if well managed, produce crops in large volume. However, even if management is efficient (a major problem of large schemes in Africa), this by no means proves their economic viability, bearing in mind the intensity of long and short-term capital investment required for their support. Low international prices for sugar and cotton are now threatening the very survival of some of Africa's largest schemes.

Some of the especial weaknesses of large-scale schemes have been:

- oversized government administrations, leading to excessive recurrent costs;
- lack of management and technical skills;
- lack of consistent government policy and failure to plan for the medium and long term;
- political interference in technical and economic decision-making, and a failure to delegate authority as well as responsibility;
- lack of foreign exchange for such essentials as fuel, spare parts and replacement machinery;
- failure to give adequate returns to farmers, leading to their abandoning the schemes.

The case for small-scale irrigation is that many of the above weaknesses can be avoided. In theory, at least, the advantages of the informal rather than the formal approach include:

- the initiating of a development process rather than a once and for all change, and thus greater flexibility;
- the encouragement of self-reliance through learning-by-doing and less radical technology change;
- lower requirements for infrastructure and long-term investment;
- the mobilization of human and capital resources at the local level, with less external intervention;
- a reduced level of initial capital cost which facilitates earlier project success.

The advantages are not automatic. The small size of a project is no guarantee that its technical and management problems will be simpler. Small-scale schemes can be at least as vulnerable as large ones to adverse trends in international trading and to failure in support systems - as for instance in the acquisition of materials and fuel, and in the repair and maintenance of pumps and other equipment. Nevertheless, in some countries, small-scale irrigation has proved to be dynamic, innovative and successful in recent years.

Of the options available four may be worth exploring:

i) rigorous revision of existing large schemes. This may involve rehabilitation, and radical improvement in management;

ii) the pursuit of more small-scale informal schemes. This will require the minimization of costs in conjunction with a less intensive system and a lower level of output value;

iii) the search for more opportunities for medium sized or village schemes. If wisely planned and managed with local involvement this may avoid many of the serious problems of both large formal and small informal schemes;

iv) the direct stimulation of individual farmers through the manipulation of input and product prices by taking small steps in water resource development.

### II.5 New Projects or Rehabilitation and Improvement?

The difficulties of many of Africa's older schemes in maintaining earlier levels of performance are a cause for concern. They are evident in the wide gap between appraisal estimates and output, in equipment breakdowns, inadequate maintenance of canal systems, poor drainage, siltation, weed and pest infestation, and salinization in some cases. In these circumstances, should a country devote scarce technical capabilities and capital to establishing new schemes or to rehabilitation and improvement of existing schemes ?

The arguments for rehabilitation and improvement are strong if it is accepted that: (i) the best, and the cheapest sites are normally developed first; (ii) the farmers on existing schemes are already familiar with irrigation and associated social conditions; (iii) infrastructure serving these schemes already exists.

The most common approach to rehabilitation so far pursued by governments has been physical reconstruction with donor assistance. Improvement of the management has seldom been attempted and may, in many cases, be the more urgent, either for itself or as an accompaniment to physical changes. Here the range of possibilities is large, bearing not only on scheme efficiency but on the morale and dedication of all parties. In very large schemes there is the danger that the irrigators will come to feel remote from central decision making and that management and farmers see their interests as opposed rather than common.

It is likely that changes in the organization are required which will bring the point of management decision closer to the farmer. This may be done by the decentralization of management, by the formation of farmers' associations. Changes in policy and more flexibility in cropping patterns and price incentives may also be introduced to make the irrigation "package" more attractive to the farmer.

If new projects are to be preferred to the rehabilitation of existing ones, then it must be shown that the net returns to investment will be at least equivalent in the medium and long term. Moreover, the mistakes which caused former schemes to decline and to need rehabilitation must be avoided in the planning, construction and operation of the new schemes.

### II.6 Institutional Options

Amongst some development planners there is a tendency, when results are disappointing, to assume that institutions are at fault, and new, improved or enlarged institutions are the answer. Since it is easier to increase staffing levels than to reduce them, and to create new institutions than to dissolve old ones, the tendency has been ever larger government services. In some countries the salaries consume so much of the regular budget that there are no funds left to provide the means for the staff to perform their duties.

Since it is the farmers who grow the crops and not the civil servants, decision making and the means to implement those decisions should be devolved as far as possible into the hands of the farmers themselves. Therefore, when considering the types of institutions discussed below, the critical question is not which institution will function most smoothly, or which will bring knowledge to the farmer fastest but which, in the long run, and given the multitudinous economic constraints at national and local level, will make most sense to the farmer.

Formal Institutions

Irrigation may be controlled or assisted by:

- a Ministry or ministerial Department
- a regional authority
- an irrigation parastatal body
- a community
- a private individual or firm.

In the first three cases government participates directly. In all five, government may be involved indirectly in various regulating, facilitating and stimulating roles.

Ministries of Irrigation or Agriculture are those most commonly involved in controlling irrigated agriculture. In countries where the irrigated subsector is large (for instance, Egypt and Sudan), these Ministries have strong influence, contributing to planning, budgetary, advisory and even executive functions. Their influence may be either direct to irrigators or channelled through regional authorities or project parastatal bodies. Diverse conditions, together with a complex history of the origins of projects, may result in a highly complex set of relations. For instance, in one country, three Departments in three different Ministries collaborate to perform the process of project identification, planning, implementation, maintenance and management, with a semi-autonomous parastatal agency for large projects - covering at present a total of some 150 000 irrigated hectares.

There are various options available to governments finding themselves in such a position:

- to concentrate more functions in one Ministry (in their case the lack of cohesion may become an intra- rather than inter-ministry problem);
- to set up a distinct ministry for irrigated areas (which, if it is to offer comprehensive services, may find itself duplicating activities of other ministries serving rainfed agriculture);
- to bring departments together in specific regions or large projects;
- to set up parastatal bodies.

Where distinct river basins exist, some countries have turned to River Basin Authorities (RBA). These can be particularly useful where a river basin lies in more than one country, and the hydrological unity of the basin can be matched by an integration of development plans and even perhaps of operational responsibilities. It must be realized, though, that development decisions and funding will contiue to be dictated by national priorities and budgets. It is important therefore that the purpose and scope of RBAs be clearly defined. However, RBAs may not be suitable in countries with a shortage of experienced technical and managerial staff. In these situations the creation of RBAs may have the effect of draining the central government of already scarce senior staff, or RBAs may become dominated by opportunists with an eye to political advantage rather than service to the community.

Parastatal irrigation bodies with the authority to develop and manage individual schemes are an attractive option if they serve both to focus the energies of a number of ministries and also to provide a degree of autonomy local enough to benefit from the collaboration of irrigators or their associations. Other forms of parastatal bodies are charged with supervision of groups of schemes reasonably similar in design and function and geographically not too dispersed - like the pump scheme corporations of Sudan. There would appear to be scope for more of these elsewhere, which either bring together hitherto separate entities or result from the breaking up of schemes which are judged to be too large and overcentralized.

Parastatal bodies can be effective as long as

- they maintain tight control over staffing and other costs;
- scheme productivity is closely monitored;
- the organization retains sufficient technical expertise in all departments;

- related functions are effectively linked - notably irrigation with agronomy;
- there is consistent policy at higher levels;
- there is a delegation of authority as well as responsibility;
- the means (including the necessary foreign exchange) are provided to do the job;
- they are left free from political interference.

Responsibility for organizing smaller irrigation operations commonly lies with the local community, with NGOs (such as church groups) or with private companies or individuals. It is likely that the relative importance of small schemes will increase in the future. In areas where these become numerous and have many similar characteristics, it may well be in the national interest to focus government assistance on them through "government service units". Such units would have the role of integrating already existing services (such as input supply, credit, extension) with the provision of others of specific value to irrigators - such as land and water resource survey, instruction in water channel construction and water application.

This challenge has already been taken up in some countries of Francophone West Africa where a great diversity of small-scale irrigation occurs, but it is important to avoid the problem found in Mali, Burkina Faso, Togo and some other countries where the diversity of terrain and water control conditions has led to the intervention of a large number of bodies, reporting to different ministries or even to private organizations, without coordination and sometimes in competition.

There may be situations where schemes, mainly of medium size can be better organized by licensed commercial companies (as for instance for sugar in Senegal and the Côte d'Ivoire). In these cases it is the role of government to negotiate contracts, which need careful formulation. If correctly managed these schemes can perform a valuable service to the national economy. Being based on the profit motive with its high input - high output approach, they are usually far removed from "grassroots" rural development with its basic aim of enhancing the life style of the people. But one need not exclude the other, and in practice there may well be need for both.

There have been some interesting experiments in "outgrower" schemes, notably in Zimbabwe but also in Swaziland and Mauritius, in which a central core estate is run on commercial lines, either by a private company or a parastatal agency, and around it land is given to smallholders who benefit from services offered by the core estate. This kind of scheme offers a promising middle way between traditional and modern commercial agriculture and between the formal and informal approaches to management.

Cooperation between Water Users

It is rare to find a case where a single water user's interest does not impinge on that of a neighbour. Certainly, as the rural population grows, to develop an even greater proportion of available water resources, compromises will have to be found between the competitive instincts of individuals and the need to cooperate for the achievement of maximum mutual benefit.

Indigenous institutions will emerge accordingly. The ways in which people react to land and water and to one another will depend on the nature of relationships between rainfed agriculture and the demands being made by the irrigation enterprises. Where there is a tradition of local cooperation for irrigation, rules will have developed by trial and error and community members will have defined roles and privileges.

Government can play a useful role in regulating, facilitating and stimulating the development of suitable institutions where these have not hitherto existed or where indigenous growth has led to serious inequities. If irrigation schemes are to furnish permanent homes and rewarding occupations for rural people, it is necessary that:

- rights and access to land and water resources be clearly defined;

- rents and charges be such as to encourage efficient use of resources;

- relationships between members of the community be regulated so as to cause

minimum tensions. This implies that existing structures should be modified as little as possible, while at the same time ensuring that

- the opportunities for increased net income be recognizably fair to all, with safeguards against progressive loss of economic and political power by the relatively poor in favour of the relatively wealthy.

## II.7 Increasing the Capacity for Irrigation Development and Management

If continued growth of the irrigation sub-sector proves to be desirable, the economy must have the capacity to handle it. The building of "human capital" is important here, and includes: i) creating the necessary technical base through research, ii) ensuring that farmers possess the skills needed; iii) improving extension, iv) developing competent staff cadres, and v) learning from experience from production schemes and pilot projects.

### The contribution of research

It is essential that farmers and scheme managers have access to reliable knowledge that enables them to achieve outputs commensurate with the resources being used. Tested crop varieties, the potential for indigenous and purchased inputs, and husbandry practices suitable for irrigated conditions must be known. Agronomic research can make a major contribution to each of these. The identification of "packages" composed of a number of these components may also be helpful, though the range of conditions under which irrigation is or can be applied in Africa is so wide that it is likely that irrigators' needs will differ widely.

As experience shows in Asia, it will be in the best interest of the irrigator to build up his own combination of innovations as experience and economics dictate. Agronomic research must therefore be able to deliver knowledge applicable to farmers' conditions, which are very different from those on research stations. Appropriate programmes for adaptive testing are necessary to take into account farmers' labour and capital constraints and the year-to-year variability of growing season. Large schemes may benefit from having their own adaptive units, as the Village Farming Experiment in the Sudan Gezira Scheme has clearly demonstrated.

### Improving Farmers' Skills

Farmers must understand the technology that is available to them. There is thus a strong case for farmers' training programmes which are linked to the innovations likely to be useful. However, there is no substitute for experience and the inventiveness that farmers show when faced with new challenges. Wherever possible, it is in the national interest that farmers' experience and skills be given the opportunity to expand. This is most likely to occur wherever the intensity of irrigation can be stepped up by degrees and where government policies in resource allocation, institution building, price adjustments, etc. give incentives to farmers to "grow".

The greatest difficulties are faced by those who, with irrigation, experience the biggest change in living conditions. These are probably formerly nomadic pastoralists to whom arable agriculture may be largely unfamiliar. Here, the older generation may never make the transition fully and a long period will be required to achieve competence. Special measures, like the incorporation of livestock into the farming system, or an organizational structure less demanding on the settler's decision-making abilities and responsibility, may help in these circumstances.

### Improved Extension

Extension should provide a two-way link between sources of knowledge (including research stations) on the one hand, and farmers on the other. Almost everywhere in the tropics extension leaves much to be desired. Its role is not understood, its importance is underestimated and therefore it is underfunded. Irrigated areas are no exception. Indeed, they may suffer, especially if extension is introduced at too late a stage in the project

implementation sequence, which may be a potent reason for early failure by the farmer and subsequent disillusion.

While the extension task is relatively straightforward in a well regulated monoculture scheme, in most cases it will be much more complex than that encountered in rainfed farming. As the use of irrigation spreads, more and more extension workers will have to become familiar with the problems it poses for the irrigator and the opportunities it creates. In all areas where irrigation is making a significant contribution an irrigation extension service is required; that is, a cadre of professionals capable of teaching the options available to the irrigator.

Staff Development

It is essential that the availability of suitably trained professional, sub-professional and vocational staff should keep pace with the expansion of irrigation, irrespective of whether large projects or small-scale irrigation dominate.

The professionals, who will include subject-matter specialists (engineers, agronomists, etc.) and managers, should receive their education at national institutions appropriately adapted for this purpose. The larger number at sub-professional and vocational level may get the bulk of their training, beyond general schooling, in service on larger schemes. But for all levels, suitable standards and a reasonable degree of homogeneity are required so as to allow mobility between projects and irrigated areas and to provide a means of staff evaluation in a career structure.

There are various typical and serious weaknesses in the staffing of organizations responsible for irrigation:

- there are shortages of staff in some categories; this arises from the failure of manpower planning to anticipate demand. For instance, there is a widespread lack of suitably trained engineers in planning units due to excessive reliance in the past on expatriate sources;

- there is too high a degree of specialization in some cadres, resulting in excessive "departmentalism". In particular, it is important that irrigation engineers understand better the end use of the water they supply, and equally that agronomists (and farmers) should appreciate and adapt to problems arising from physical constraints to that water supply;

- there is too low a level of management in many schemes. In part this can be attributed to weaknesses in organizational design and to lack of incentives to be a manager, but training can also help to correct this defect.

Training should be seen as a continuing need for all employees with periodical updating and upgrading. A range of techniques besides formal courses may be employed, which includes conferences, workshops, newsletters, correspondence and video courses.

Many irrigation staff may have had a large part of their education and earlier life in urban surroundings but, once appointed, will be assigned to rural, sometimes isolated, locations. The more isolated the posting the more penal it is rated. Being in short supply, such specialists are easily seduced by vacancies offering better amenities, more social contacts, less arduous conditions and improved career prospects. There appears to be no alternative to raising the real income of these professionals if their services are to be retained.

Experience from Schemes and Pilot Schemes

The best source of knowledge, especially for planners, subject-matter specialists and managers, is in ongoing schemes and pilot projects. There is much to be learned through the better dissemination of knowledge between countries about irrigation opportunities, achievements and problem solving in small-scheme development, the variety of approaches is vast. But because they are small-scale, and often the result of local

ingenuity rather than the product of public or expatriate agencies, the circulation of knowledge is parochial and slow.

At the detailed level, there is probably nothing better for managers than the lessons of experience gained on lower rungs of the promotion ladder. The translation of this experience into good management at senior level may be diminished, however, by:
(i) too limited a period of experience due to too rapid promotion, (ii) an inadequate grasp of field conditions and requirements due to a shortage of capable supervisors, (iii) a failure to document and learn lessons from the past, with a tendency to attribute too many internal scheme shortcomings to external factors, and (iv) a reluctance to introduce or to experiment with new products, production methods, institutions or management methods.

Pilot projects are often held up as a priceless source of experience. Successful pilot scheme results, however, can be misleading as a guide to whole-scheme organization and institutions, because the whole scheme is not a replication of the pilot scheme. Moreover, pilot schemes invariably receive more managerial attention than can be lavished on the same area within a complete scheme.

## III. ISSUES AT PROJECT LEVEL

### III.1 Management Options

It is useful to distinguish between the concept of management and that of administration. Administration is chiefly concerned with the day-to-day application of agreed rules of procedure and involves a hierarchy of people in accepted roles. Management implies the manipulation of this organization for the achievement of specific objectives. Management, therefore, entails attention to strategy and tactics, and includes the monitoring of progress which leads to decision-making and action in the light of experience gained. Control of irrigation in Africa has often been characterized by an administrative rather than management approach.

The scope of scheme management can vary widely. In some it may be confined to the supply of irrigation water, all agricultural decisions being left to farmers and their organizations. More commonly, in Africa (as contrasted, e.g. with Southern Asia), large-scale irrigation projects are conceived as comprehensive enterprises where irrigation water is the major but not the only resource assembled for the production and marketing of one or more products on a significant scale. In this case, management extends comprehensively over all parts of the process. The administration bias and compartmentalization of government agencies are inappropriate for the focused management of such large projects and a semi-independent, probably parastatal organization is necessary. Even these, however, suffer from a tendency to subordinate management to administration.

The dominant objectives of irrigation projects are now changing. While the objective of increasing output remains, it is less likely that this will be achieved in the form of a single cash crop. The national demands for food, the demand among project farmers for a secure living with higher standards of amenity and health, and the need to sustain the usefulness of projects into the indefinite future are now major considerations. This alters the parameters of the management task.

The criteria of success in future are likely to be: (i) meeting the farmers' needs, (ii) sustained efficiency of the use of resources, (iii) a strong sense of unity of purpose and attachment to the project by management and farmers alike, and (iv) minimization of class distinctions and income distribution consistent with that required to provide incentives to improve and succeed.

The tasks of management are also likely to change in future. The trend towards an increase in the relative importance of small schemes and the indigenous growth of irrigation means that the role of government-employed management is likely to move towards a stimulating rather than participative role. This may be paralleled by a tendency in existing large schemes, where the original organizational structure was monolithic, to move to some weakening of centralization if the desirability of local diversification of output and production methods becomes more apparent. In such circumstances, farmers and their group leaders will have a greater say in management.

Governments, therefore, have options in the design of new or rehabilitated schemes, in which management can: (i) seek to achieve targets expressed either in narrow "output" terms or in the broader terms of resource productivity and social progress, (ii) establish either fully detailed rules for farmers governing day-to-day irrigating and cropping procedures or a framework of resource and service supply and cropping procedures which irrigators can, within limits, utilize as they wish. Though circumstances will differ from place to place and change over time, it is likely that future management will be concerned with broader targets and looser methods of control.

III.2 **Containing Costs**

Low prices for exported and urban-consumed commodities, and constraints on budgets which derive, in part, from a shortage of foreign exchange, mean that African governments have no choice but to pursue cost containment measures in irrigation projects. There are three broad options, which are not mutually exclusive:

- ways can be sought to reduce costs by increasing operational efficiency;
- functions hitherto performed by government can be transferred to the farmers or to private enterprise in the service sector;
- a higher proportion of the costs incurred in providing services to farmers can be recovered through rent and rate charges.

Success in the last two options does not necessarily mean that there are net benefits to society as a whole. However, gains may arise from making the recipients more directly appreciative of specific services, through paying more for them or having a choice of whether or not to have them.

Cost Reduction or Transfer

Cost reduction or transfer may be considered under subheads. The first of these, infrastructural costs, particularly housing and related structures, often figure prominently in large-scale irrigation projects. The high cost of house building seems an unwarranted burden on an irrigation project and may be better left to the private sector. Other infrastructural costs like roads, railways, communications, health clinics, etc. may be incurred as the project (which is part of the rural sector) demands, but charged to general government expenses and covered by tax income.

Fixed investment costs, once incurred, cannot be reduced. There is currently much discussion about whether these have tended in the past to be too large or too small. An example of the latter is the failure to line canals with consequent heavy seepage losses, but the predominant feeling is that high initial investment costs have been accepted too readily. The investing government may however have the option of phasing some of these costs over time more intelligently in relation to scheme development and income generation. Even so, by its nature, irrigation development will involve heavy expenditure in advance of revenue earning.

Recurrent costs merit equally close scrutiny. These comprise chiefly the goods and services required to keep the fixed investment in continuous use, and the establishment costs covering scheme personnel. While the former are not infrequently neglected, resulting for instance in the siltation of canals through inadequate cleaning, the latter are often excessive and politically hard to keep within bounds. Improvements in both categories may follow an improvement of the accounting system to allow a more accurate categorizing of costs against the programme of necessary functions.

Variable cost reduction is more pertinent to agricultural production than to the associated irrigation (except where water pumping is involved). The options available to government may be to reduce or eliminate subsidies attached to the supply of inputs, or to cease to recommend the use of these variable inputs at a level which is frequently uneconomic. The provision of goods and services at competitive prices by private enterprise to autonomous and well trained farmers, and backed up with reliable infrastructure, is likely to be more efficient than by public agencies, with overall cost-saving and a transfer of

expenditure from government accounts. However, care is needed in cost reduction. For instance, whereas public services may be available to all farmers whatever their size of operation and location, this uniformity of access may be lost if the task is left to private enterprise. Also, some irrigation schemes in the short to medium term may be located in areas too remote for established private enterprises. It may then be necessary to retain public input services of the kind described until circumstances change to encourage private support.

Cost Recovery

Cost recovery is a matter partly of institutional arrangements and partly of operational efficiency. Recovering costs from users of irrigation water remains a key policy issue. The options are (i) to seek to recover both capital and recurrent operation and maintenance (O&M) costs; (ii) to recover only O&M costs; (iii) to recover no costs at all.

Some argue that all costs should be recovered in land and water charges, while others point out that equivalent charges are in fact recovered by way of export or trade taxes on sale products, although these tend to act as disincentives. Some consider it is unrealistic to charge at all for water on the grounds that this would be an intolerable financial burden to poor people, while others argue that effective cost recovery is the only way to induce a sense of economy into water utilization. This latter view assumes that the farmer has full control over the water he takes and can judge what is most economical. In practice, this position may only apply where a farmer is buying metered supplies (normally pumped water) and where he can choose how much to take. Probably the commonest position now taken by policy makers is that farmers should be expected to pay a fixed water rate for operation and maintenance in centrally managed irrigation schemes, though there is pressure, partly from donors, to raise the target level of recovery.

Collection of payments presents problems in practice. The best way (as with recovering debts in credit programmes) is to link water charges with the production of one or more commodities which are marketed by the project, when they can be deducted before the revenue is distributed. Even this method may be subject to severe political pressure by farmers in years when, due to failure of crops and/or market prices, the revenue is small.

### III.3 **Improving Returns**

Because such a high proportion of costs in irrigation is normally fixed, improving returns may be easier than reducing costs (at least of irrigation itself). This implies raising product prices, yields or both. Some of the options are:

- moving to higher value products
- intensifying cropping
- raising the labour supply
- raising the capital supply
- improving the integrated use of the irrigated and surrounding area.

Higher Value Crops

There are cases where the demand for higher value crops justifies irrigation in the first place or whether they can be introduced as market access and consumer tastes change. For instance, urban growth in close proximity to an irrigation project may stimulate the growing of fruit and vegetables and the use of agricultural products and by-products for fresh milk or meat. To warrant this, marginal revenue must exceed all marginal costs. Changes in the pattern of irrigation may present problems if they depart significantly from the design conditions of discharge and timing, and flexibility in the initial system design can be a great asset in adapting to such situations.

Crop Intensification

Crop intensification may be possible where water supply and system flexibility permit. This may be a potent way of reducing fixed costs per unit of output but may cause problems. If dry-season irrigators also grow food staples on rainfed land, extending the irrigation season on nearby land may be constrained both by labour shortage and low re

turns to water. Intensification in some areas may entail the reduction or elimination of fallow which provides opportunity for weed and pest control and some animal grazing, all at low cost. Crop intensification may also demand investment to strengthen supply services and infrastructure. Adverse climatic factors may cause the timing of a two-crop cycle to be too tight for scheme management.

Crop intensification may also take the form of multipurpose water in canals, ponds and even flooded fields - to raise fish or ducks, thus adding to income and diversifying diet.

Labour Supply

Necessary labour can be raised by the hiring of seasonal or migrant labour. Alternatively, the size of holdings within a scheme may be reduced if the population within the scheme area grows over the years and the scheme continues to present attractive opportunities for income. In practice, the inflow of settlers and pressure to subdivide holdings may be connected with complex social changes. The additional labour will increase the scheme's net output only if the marginal returns to labour are positive, dependent on the possibility of intensifying cultivation and using water more efficiently. Otherwise, the value of the product is merely shared between more people. Undesirable side effects of the reduction in holding size must be countered. These pressures and changes can also be expected to affect both the natural environment and communities in neighbouring areas.

Capital Supply

Raising the capital supply may be an option for the purpose of augmenting the productivity of land or labour. In some schemes, for instance, increased credit would result in a higher level of use of short-term inputs. In others mechanization can substitute for seasonal or overall labour shortage or reduced drudgery. These options demand that the innovations concerned are technically feasible and economically sound, the support services can cope, and foreign exchange can be assured for supplies of imports such as fertilizers, fuel or equipment.

Improving the Integrated Use of the Irrigated and Surrounding Areas

This concept has not always occurred to scheme planners or managers. Disappointments have arisen as a result. The numbers of settlers expected have not been forthcoming because the attractions of the scheme have not been sufficient to draw them away from their traditional rainfed arable or pastoral pursuits, or settlers have made a lower-than-planned contribution because of alternative sources of income outside the scheme. On some projects, the needs for fuelwood, unplanned for in the scheme, have resulted in deforestation and soil erosion outside. These are examples of bad planning with consequent under- use or loss of resources. It is important that planning takes into account the relationship of the scheme to its environment and that past experience is documented, widely circulated, and used as object lessons for future planning.

## III.4 Choosing and Changing Technology

Using "technology" in its widest sense to cover both know-how and associated hardware, it is clear that the character and success of irrigation schemes are strongly influenced from the outset by technological choices as these apply to the acquisition, transport and distribution of irrigation water and to agricultural methods. Moreover, technological choices, especially in scheme construction, may be so costly and constraining that later freedom of manoeuvre is seriously restricted.

In the planning, design or revision of an irrigation project it may be necessary to examine a range of technology options. For each option it will be necessary to estimate its costs (in terms of fixed and variable components) versus any costs saved, to estimate linkage effects to other costs such as infrastructure and maintenance of machinery and to estimate linkage effects to the pattern of income. In the latter case, the beneficia

ries from the innovation should be identified, whether these are the small or large farmers, landless labourers, the traders or bureaucrats.

In parts of Asia, irrigation has advanced through a series of phases of intensification from small-scale diversion ensuring the yield of a short-season crop, to larger diversion to support a long-season crop, to a system of dams and barrages to water a larger area on a perennial system of cropping. The level of technological sophistication appropriate at any one time will depend on relative price, as well as the skills and the needs of managers and the local people. Long-term effectiveness is likely to be greatest if the technology chosen is appropriate to the present and medium-term future, and if flexibility is retained.

### III.5 Farmers' Involvement and Government Support

The evidence suggests that African irrigation is entering a new era. The recent past was characterized by big projects, heavy investment and imported technology with sophisticated planning and construction skills. These were intended chiefly to increase exports or substitute for the food imports demanded by urban consumers. Irrigators played a minor role and had little say in operational decisions. This type of scheme will be increasingly supplanted, and its conditions of operation probably modified, to take account of a dispersed demand for more diverse products, among which foods will predominate, making use of many scattered often small sites at lower technological and less ambitious organizational levels. Farmers and their local organizations will take a more prominent part with private entrepreneurs providing input and marketing services. Governments will continue to be involved but their role is beginning to change.

Scheme Establishment and Management

In many countries, especially in Asia, long dependence on irrigation water has meant that local farmers, their families and community leaders are thoroughly versed in irrigation technology. By trial and error, systems have been slowly evolved, sometimes to a high level of technical and institutional complexity. The level of government support and involvement has been commensurate with the role of irrigation as the basic mode of farming.

In Africa, where population pressure has been less than in Asia, there has been less need for farmers to mobilize themselves for the establishment of irrigation, and on "formal" irrigation schemes the authorities have been reluctant to allocate management roles to the farmers, particularly schemes where the settlers may have had little previous experience of irrigation. The situation is changing in many traditionally rainfed areas and also in existing irrigation schemes where there is increased preoccupation with the need for farmer cooperation. In both cases the preferences of the direct beneficiaries are receiving greater recognition.

Governments have the option of ignoring the interests and preferences of the local inhabitants on the grounds that the government is best placed to take policy decisions. But this risks a lack of popular support or even resistance to change. The introduction of irrigation is more likely to be effective if it can be accepted by the community on its own terms or at least through a partnership. Moreover, rather than impose new institutions, involving for example highly centralized accounting procedures or "Western" type cooperatives, local institutions may be adaptable to regulate and facilitate irrigated agriculture with minimum disturbance to the prevailing life style.

In subsequent management of schemes, progress will be faster and smoother if the relationship between the beneficiaries and the government and agencies is characterized by collaboration rather than confrontation. A range of options can be grouped under the following broad sub-types:

- in small schemes in particular, the irrigators may be responsible for all management, with government agencies or departments providing only supporting services;

- management of medium-sized schemes, or sections of larger ones, may be the respon-

sibility of public servants assisted by a management committee of participants' representatives;

- management, especially of large schemes, may be in the hands of a management team, with provision for consultation with irrigators' representatives.

Whatever detailed system of management is chosen will depend on local circumstances at the time of scheme establishment or major revision. Precise prescription is impossible but there is growing belief that some form of farmers' association is required. In some cases, this may be capable of virtually complete control of the irrigation system. In others, it may act mainly as a channel of communication between government and scheme participants.

Increased Subsistence Security

The future expansion of irrigation must take cognizance of the need for adequate food supply, forage for livestock and fuelwood. The expenditure of scarce national funds to assist the expansion of local food production where this is at risk, will earn the approval of the local community, it will save foreign imports as well as internal transport and distribution costs. In contrast, the establishment of specialist irrigated schemes, leaving the community dependent on outside food supplies, is likely to create periodic crises and disaffection.

Food security is also important in existing schemes. In some of these, a family's right to grow food crops, fodder and fuel, either within the rotation or on a separate area, was incorporated in the original plan and has been maintained. It is desirable that it should be so in all schemes, taking care of the basic needs of the community and increasing its sense of commitment to the whole enterprise, even through periods of greatest stringency.

More Attractive Prices for Products Sold

African farmers are price responsive. Reluctance to become involved in irrigation, and dissatisfaction when committed are common reactions of farmers to the financial risks inherent in high input farming in the face of low and often unpredictable prices. Low prices are a particular deterrent if a cash crop is labour-intensive and competes with farmers' food crops. Planners assume too readily that the labour of the irrigator's family is "free" or of low opportunity cost, thereby over-estimating farmers' potential profit margins, whereas the evidence frequently points to the availability of other sources of income. One of the most important government options is to raise farmers' prices in general and, within formal irrigation schemes, to seek ways of raising and stabilizing farmers' net incomes. The latter may be achieved through the creation of a reserve fund.

Changes in Land and Water Institutions

As a rural population grows and land becomes scarce there will be pressure to cultivate it more intensively and to have permanent access to it. Though local traditions will influence the exact outcome, it is likely that land will become increasingly an owned, tradeable and bankable asset. Security of tenure with its incentive to maintain and improve land will become increasingly attractive to farmers. The advent of irrigation will intensify this trend. Within existing schemes, security of tenure is prized and its achievement can increase farmers' commitment to high performance.

As with land, the definition of water rights will be influenced by local custom. Similarly, irrigation water is likely to get progressively scarcer in relation to demand, and local communities, within the framework of government guidance and control, must find ways of establishing equitable access for individual households. Experience in areas long irrigated, and however tightly regulated, shows that water rights become closely associated with land. Irrigation development therefore reinforces the inequity in income distribution already evident in the land tenure system. This danger must be anticipated to protect the poorer section of the community.

## IV. CONCLUSIONS

Irrigation differs from other forms of agricultural development in several major respects. It requires the coordinated management of two separate natural resources, land and water. Each of these demands special technologies, skills, professional staff and institutional arrangements, sometimes extending to the level of government ministries. Irrigation normally requires a high initial capital investment per unit area, sometimes long before the start of any benefit stream. It will often cause fundamental changes in the environment, and will certainly profoundly affect the indigenous farming systems and way of life of its practitioners.

Irrigation may be seen as a means to achieve one or more of the following national objectives, which may or may not be compatible:

- increasing national income
- earning (or saving) foreign exchange
- increasing food security - nationally and locally
- increasing farmer incomes
- providing rural employment and reducing migration to urban areas
- settling drought victims or landless people
- conserving dry-farmed areas

Key factors in decision-making for the development, rehabilitation or improvement of irrigation will include:

- water use priorities - national, river basin, local

- the level of irrigation, whether high, medium or low in terms of costs, inputs, technologies and outputs, and the associated economic and social implications

- acceptability to farmers in relation to such aspects as crop preferences and effect on nutrition, land tenure, labour availability and skills, social organization in cooperatives or farmers groups, the role of women in irrigation farming.

Irrigation planning therefore calls for knowledge on a large number of physical, economic and social variables, and on the interrelations between them. It also requires the setting of priorities of national and community objectives. Furthermore, all these factors, and indeed objectives, will change with time. Thus, monitoring of irrigation performance and feedback to the policy and planning level is needed to maintain the dynamic technical, social and economic system needed in a successful scheme.

These may be heavy demands on the planners and policy makers. But, a small investment in better standards of irrigation planning will yield huge dividends. A major reason for the disappointing performance of irrigation in many African countries may be that the process of systematic irrigation planning and policy formulation has not yet started.

Countries are not alike. Resources, problems and political ideologies differ widely. Thus no single policy package can be offered. However, past experience has already identified the principles and practice of irrigation policy formulation and planning and this knowledge can now be applied at national, provincial and local levels.

Doc. I-B
(Original in English)

# IRRIGATION AND WATER RESOURCES POTENTIAL FOR AFRICA

**SUMMARY**

FAO is now preparing a 1 to 10 million scale map of water and irrigation potential for Africa. This will be accompanied by tables of potential water and irrigable land for each of the major river watersheds defined in the study. The work is based on digitized cartographic data using a geographic information system (GIS)/software. The methodology used is basically the water balance approach, which depends on the validity of the rainfall data.

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## I. BACKGROUND

The soil and water resources of Africa are well known in some places, reasonably well known in others, and unknown in a large part of the continent. Furthermore, where soils are known in detail, the water availability may not be. It has, therefore, been very difficult to make a first assessment of the irrigation potential and water resources of Africa. The FAO/UNESCO Soil Map of the World provides a consistent basis for such a study.

In 1980-81, FAO digitized the Soil Map of the World along with national borders and agro-ecological zones (AEZ). An attempt was made at that time to assess irrigation potential but it soon became obvious that it was essential to have river basin boundaries.

With increasing capacity and decreasing costs of computers, many complex software packages have been developed as well as related hardware for processing of geographic information. By 1973, the first geographic information system (GIS) had been developed, as well as the hardware needed to input and output map data. These systems have improved as computers have improved and as use of GIS increased. Powerful and relatively easy to use software is now available.

The United Nations Environmental Programme (UNEP) in 1983-84 financed a study on desertification hazards which was carried out by FAO. Of major significance to this irrigation study was the fact that a new GIS data base was prepared for the Desertification Project. For Africa a large amount of information was digitized while less was digitized for the rest of the world.

Because of FAO's emphasis on Africa, and the need for consistent information on water and irrigation potential, the possibility of using the digitized map data from the Desertification Project was investigated. This investigation started in mid-1984 when the data became available and has continued. This paper presents a brief description of a methodology and initial results for the whole of Africa.

## II. PRELIMINARY RESULTS

This paper presents, in a preliminary way, Africa-wide results and stresses their implications for irrigation planning in the future. The results by country and by groups of watersheds are available and will be presented in a final report.

One of the more important conclusions is the relatively small proportion of soils which have few soil physical constraints for irrigation of major food crops such as maize and millet. These are called best soils for upland crops. Out of a continental total of about 30 million km², only about a half million km² fall into this category. Of 48 African countries, 36 have adequate water for irrigation of these soils and 12 have insufficient water.

Suitable soils for upland crops include soils with minor constraints for irrigation. When best and suitable soils are considered there is a total of about 3.5 million km², with water, however, for only about 2 million km². There are 21 countries with water to irrigate all of these soils and 27 countries where water is not available for all of the soils.

Another major result of the study is that soils suited for rice are more extensive in Africa than soils for upland crops. There are roughly 1.4 million km² of best rice soils and about 4.2 millions km² of best plus suitable soils.

There is water to irrigate about 1 million km² of lowland crop best soils, and about 2.2 millions km² of lowland best plus suitable soils.

The total estimated useable water resources is about 3000 km³ for all of Africa. The maximum water requirement for lowland crops best plus suitable soils would be about 1900 km³. Further water use would require major transport between river basins.

While further consequences on food, fibre, and animal production will be investigated, the 0.3 to 2.2 million km² of irrigable soils with available water could theoretically provide food grains for 10 persons per hectare or 300 to 2200 million people.

Distribution of irrigable soils with water resources follows fairly closely the distribution of potential rainfed agriculture. Costs for irrigation will generally be higher than for rainfed crops alone, but many regions will no doubt have both, with irrigation used to produce the higher value crops.

## III. OUTLINE OF THE APPROACH

The first task was to become familiar with the details of the data base. A small area of Africa was chosen (a "window") and a map of each of the data sets in the window was obtained using the GIS data base at a magnified scale but at a size that was easy to handle. The details of the data base (names and definitions) had already been prepared as a report.

At the same time, several ways to use the data base were explored. This was done by breaking the methodology into various components and physically overlaying maps by hand for the window to see which method produced reasonable results.

In early 1985, a computer was used to produce overlays for the window and a methodology was chosen that gave reasonable results. With some modifications this methodology was then applied to the southern third of Africa. The results were reviewed, several modifications were made and applied to Africa as a whole in early 1986.

## IV. METHODOLOGY

The methodology is based on a water balance approach. The suitability of soils for irrigation is determined and amount of water needed to irrigate the soils is estimated, giving potential irrigation use. Surface and groundwater resources are then estimated and compared to the potential irrigation use. If potential irrigation use exceeds available water resources, the area that can be irrigated is reduced accordingly. If there is a water surplus, some of it is routed to a downstream basin, if one exists. The water balance is prepared by watershed and country. Some additional details on the methodology are presented below.

### IV.1 Suitability of Soils for Irrigation

The FAO/UNESCO Soil Map of the World was used as the basic source of information since it was available in digitized form. As part of this digitizing, a comprehensive file of soil attributes provides easy access to information on the dominant, associated and included soils obtained during original preparation of the map. Attributes include slope, drainage, texture, and phase, all of which were used in the evaluation of the component soils.

The basic irrigation properties of all soil components have been evaluated and criteria established were used to estimate the proportion of each component soil which would meet irrigation requirements.

In addition, criteria were established for two major crop types. One is the conditions for growing most food crops under irrigation, except for lowland crops. The second was criteria for lowland crops which in Africa are mostly flooded rice. Since the distribution of the suitable soils for these two conditions are not always similar, upland or lowland, or both, will be specified in the results which follow later.

The four main irrigation classes which have been developed by FAO soil experts are:

S1 - Irrigation with no constraints

S2 - Irrigation with some constraints

N1 - Irrigation with serious constraints

N2 - Unsuited for irrigation.

Certain soils, land units, and/or phases may be clearly classified as unsuitable for irrigated agriculture and can be immediately classified as N2. These include:

a) Lithosols(I) since their depth is defined as less than 10 cm.

b) Arenosols(Q), Regosols(R), and Vitric Andosols(Vt) are considered excessively drained due to their coarse texture and are generally poor soils.

c) Rendzinas(R), having high calcium carbonate, are poor soils.

d) Yermosols(Y) are limited by stony, lithic, or petrocalcic soils, salt crusts, and shifting dunes.

e) Podzols(P) have a low fertility and a leached surface horizon and are therefore deficient.

f) Thionic Fluvisols(Jt) are not suitable owing to toxic elements, high post-drainage acidity, high salinity and often nitrogen deficiency. However, some of these factors are favourable for flooded rice.

g) Miscellaneous land units, such as rock debris or desert detritus(RK), salt flats(SF) and dunes or shifting sands (DS).

h) Gypsic units(y), which are too high in calcium.

i) Soils with stony, lithic or petrogypsic phases.

All remaining soils are first considered irrigable and further modified according to the constraints listed above.

The final irrigable percentage of each soil component is adjusted by the percent of that component contained in the soil map unit. The percentage of each component in each class (S1, S2, N1, N2) is totalled for the soil map unit.

The inclusion of S1, S2 and N1 as irrigable provides the greatest area. Since N1 soils are irrigable only if serious soil constraints can be overcome, they are not included in this report as irrigable. Analysis using only S1 would provide the smallest irrigable area. The analyses which follow later limit consideration to best soils (S1) or best and suitable (S1 + S2) soils.

The best soils for upland and lowland crops are often, but not always, located in different areas and have different percentages of irrigable land. Because many soil map units include more than one associated soil, a soil unit may have both upland and lowland potential, but it is not possible to determine their exact locations within the soil map unit.

### IV.2 Irrigation Water Requirements

The irrigation water requirements in millimeters (mm) are needed to calculate the requirements in terms of volume which can then be compared with water supply in the water balance estimates. A considerable study was made of crop water requirements for a range of crops in the various African climates during the time of the year when irrigation would be required. In spite of both single and double rainy seasons and a wide range of temperatures, it was found that a relatively simple relation exists between annual rainfall and the crop water requirements for the African food grain crops. In addition, it may be noted that water requirements for food grains lie between fruit and vegetable crops and fibre crops. No attempt was made to produce complex crop patterns.

The irrigation water requirement assumes an irrigation efficiency of 50 percent. The water requirement, W, can be represented by the following equation for Africa, where R is the average annual rainfall in mm.

$$W = 1672 \exp(-4.98 \times 10^{-4} R)$$

### IV.3 Irrigation Water Requirement for Watersheds and Countries

The digitized rainfall map is overlaid on the maps of soils, countries and the watersheds. The volume water requirements for each area is calculated by multiplying the area by the percent of irrigable soils and the crop water requirement in mm.

The water requirement for the watershed and country is obtained by adding the water requirement for each included area. While this procedure gives results which are useful for general planning, it does not take into account all the variation in relative location of irrigable lands and water sources within watersheds.

### IV.4 Water Resources

Surface water resources

Surface water resources are estimated to be 50% of the estimated runoff during the rainy season. However, instead of using average annual rainfall the 4 out of 5-year (80%) rainfall was used to give results which are conservative. Irrigation in theory should have water for every year, but in most places this requires long-term carry-over storage.

80% rainfall probability

A large number of rainfall stations were analyzed to obtain a relationship of the variability with mean annual rainfall.

Drought risk studies

During the probability analysis it was apparent that a preliminary analysis of drought risk might be made. About 200 stations were analyzed to determine the number of times in 50 years that the 80% rainfall was not reached in two or more successive years. As would be expected, the drought risk increases as average rainfall decreases.

Rainfall-runoff relations

The number of rivers in Africa with measured flows is limited. An analysis was carried out of the previous runoff estimates and of available measured flow. It is clear that there are regional variations in the rainfall-runoff relations. Many of these appear to be the result of inadequate data and, therefore, an Africa-wide relationship was assumed using the mean annual rainfall. The relationship was further modified to use the 80% rainfall instead of the average for estimating useable surface water. The lower limit of usable water based on average annual rainfall is about 400 mm. However, taking the 80% probability into account, there is no usable supply below an average annual rainfall of about 575 mm.

### IV. 5 Groundwater Resources

The digitized map data included the UNESCO Geological Map of Africa, as well as landforms, salt cover, dissection and drainage. These parameters were used to first estimate the water-yielding capacity of the rocks.

Even where the rocks may be capable of yielding large amounts of water, the aquifer yield may be limited by groundwater recharge. A considerable study was carried out to review various methods for estimating groundwater recharge. While very sophisticated methods exist (as with surface runoff), it was necessary to use the direct relation with rainfall. The rocks were ranked according to their water-yielding capacity and amount of recharge estimated for each rainfall. The smaller of the two values (yield or recharge) was taken as the groundwater potential in mm.

The estimated groundwater potential in mm is multiplied by the area of the aquifer and the groundwater resources are assumed to be 50% of this value. As with surface water, the groundwater resources are summed for each watershed in each country.

The areas with average annual rain of less than 200 mm are considered to have negligible groundwater recharge over a long time period in comparison with even limited irrigation. Thus, groundwater mining is not considered in this study.

### IV.6 Delineation of Watersheds

Watersheds were delineated on 1:5 million scale maps by FAO. Since the original intention of the water resource study was to assess important river basins, but not in great detail, it was necessary to group many individual rivers together.

Large river basins pose a problem due to their size and complexity and the fact that they are often in two or more countries and, therefore, are further analyzed by country.

The national boundaries which follow rivers and which follow drainage divides, were checked to a limited degree for accuracy. However, it is known that some national boundaries were established when accurate maps were not available and are different from watersheds as shown today on most maps.

### IV.7 Water Balance

The total of the surface and groundwater resources are added for each watershed/-country and compared to the total water requirements. If the resources exceed the requirements, there is surplus water.

When there is no downstream watershed or country, no changes are needed. When there is a downstream basin or country, then the surplus surface water resources are routed downstream to the next area. It is assumed that movement of groundwater downstream is negligible. It is also assumed that the remaining 50% surface water would either not be available at the right time or is used within the watershed by natural evapotranspiration.

When the irrigation water requirements exceed the resources, the area which can be irrigated is reduced proportionally, and no surface water is routed downstream.

Water routing

After the watersheds were digitized and overlaid on the country boundaries, it was necessary to prepare a special table for the water balance computation in order that any surplus water could be routed downstream to the proper area.

The case where there was only a single watershed within one country which drains directly to the sea requires no modification.

Closed drainage basins are generally in relatively arid areas and most water

resources would not travel far. Therefore, it was assumed that routing from one country to another in very large closed basins would not occur.

It was assumed that downstream movement of groundwater is negligible.

For those watersheds which have two or more countries and which have been divided into smaller watersheds, a relatively simple procedure was used to route any surplus surface waters downstream. More detailed maps were used to be sure that water was routed in a downstream direction. It is not always possible to be precise at the scale of this study, but the bulk of the routings are essentially correct.

**Doc. II-B**
(Original in English)

# IRRIGATION DEVELOPMENT IN SOUTHEAST ASIA - SOME RECENT EXPERIENCES OF FOUR COUNTRIES

SUMMARY



This paper is based on a report prepared by Mr. Benjamin Bagadion, National Irrigation Administration, Manila, The Philippines.

**SUMMARY**

The total irrigated area in Indonesia, Thailand, the Philippines and Malaysia is about 9.5 million hectares, some 52 percent of which are in Indonesia, 29 percent in Thailand, 15 percent in the Philippines and 4 percent in Malaysia. These countries are all tropical and monsoonal, with annual rainfall in each country varying from 1400 mm to over 2000 mm depending on location. The principle irrigated crop is paddy. Irrigation is needed in the dry season as well as in the wet season to provide water during dry spells.

As population and food requirements increased, irrigation development became a national concern in each country. As a consequence, the governments initiated irrigation programmes as part of overall national development plans. These programmes aim primarily at achieiving self-sufficiency in food.

On the whole, the irrigation development programmes in the four countries have yielded benefits. They include increased employment during construction and increased agricultural activities when the system becomes operational. Yields per hectare have increased in areas where dependable water is available. There have also been increases in cropping intensities. The increased agricultural activities stimulated a rise in general business activity. Roads constructed as part of the projects enhanced social interaction. Some projects were for multiple purposes and where power was a component, the project eased the energy problem. Finally the projects helped attain self-sufficiency in rice in the Philippines and Indonesia.

While substantial benefits have been obtained from the irrigation programme in the four countries, much remains to be realized: in most irrigation projects the benefits have not yet reached all target areas. Constraints include:

- lack of funds for construction, which has delayed the completion of projects and restricted irrigation activities;
- lack of funds for operation and maintenance, resulting in inequitable water distribution, poor maintenance and progressive loss of system capacity;
- difficulties in implementing a cropping calendar that optimizes water use, largely due to delays and uncertainties in the supply of agricultural inputs, and lack of communication between farmers and irrigation operational units;
- lack of participation of the farmers-water users;
- lack of incentives for, and training of, operation and maintenance personnel.

Experience shows that farmers' participation is a key factor in the successful development of irrigation. However, appropriate methods and policies to motivate and train farmers for effective participation are still in an early phase of development. Pilot projects to test new concepts and methods are being conducted in the Philippines and Indonesia and are underway in Thailand. In the communal projects in the Philippines irrigation associations now readily accept responsibility for the operation and maintenance of the system, and for repaying the cost of construction. In this as well as in the national projects canals are better maintained, fee collection has increased, rules are more effectively respected, and some increase in irrigated area has been reported.

Early results point to the importance of strong government support for participatory approaches, training at all levels, the need for an adequate budget for recurrent costs, new attitudes of irrigation personnel, revised procedures and methods to assist the farmers, the establishment of appropriate farmers' mobilization strategies, and the building of a capacity in the irrigation agencies to respond to farmers' needs.

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## I. BACKGROUND INFORMATION

### 1.1 Irrigated Area

The total irrigated area in Indonesia, Thailand, the Philippines, and Malaysia is about 9.5 million hectares, about 52% of which are in Indonesia, 29% in Thailand, 15% in the Philippines, and 4% in Malaysia. These countries are all tropical and monsoonal. Temperatures in the lowland irrigated areas range between an average minimum of about 22°C and an average maximum of about 31°C. Each country has a wet and a dry season. While annual rainfall in each country varies from 1400 mm to over 2000 mm, depending on location, most of it occurs during the wet season. The principal irrigated crop is paddy and, as even during the wet season dry spells occur that adversely affect the rice crop, irrigation is needed during both seasons. Other irrigated crops are sugarcane, bananas, corn, tobacco, and short period vegetable crops.

Before governments initiated irrigation development programmes, small irrigation systems were already in existence in the four countries. In Northern Thailand about 300 000 hectares of people's irrigation systems, many larger than 700 hectares, were constructed by farmer groups more than 200 years ago. The farmer-constructed "subak" irrigation systems in Bali, Indonesia, cover about 100 000 hectares, while the irrigated rice terraces and the "zangera" irrigation systems, in the Philippines, also built by farmers, serve about 25 000 hectares. Similar small schemes can be found scattered in Malaysia and the Indonesian islands of Java and Sumatra. Individually, however, these schemes were small and simple, consisting of temporary dams and earthen canals that allowed water to flow to lower lying paddy fields. At the time of their construction they were adapted to the needs and circumstances then prevailing. Many of these systems still exist and are being considered by Government irrigation agencies for further improvement as part of irrigation development programmes.

In areas covered by government irrigation programmes farm holdings average about 4 hectares in Thailand, 2 hectares in the Philippines and 2 hectares in Peninsular Malaysia. In Indonesia the farm holdings vary considerably in size, from an average of 0.4 hectares on Java to about 3 hectares on the outer islands of Sumatra, Kalimantan and Sulawesi. In the Philippines land tenancy is prevalent and a land reform programme has been effected. Under this programme paddy land is subject to government purchase for distribution to tenants if the area owned by one individual exceeds 7 ha. In Thailand and Malaysia ownership of lands is more evenly distributed than in the Philippines. In Thailand a land reform programme is being implemented to further improve ownership distribution. There is also a pilot land consolidation programme to improve irrigation water management. In Indonesia a transmigration programme is underway to resettle farmers from densely populated Java on the islands of Kalimantan, Sulawesi and Sumatra.

### 1.2 Role of Government

As population and food requirements increased, and strong central governments emerged, irrigation development became in each country a national concern. Consequently the governments initiated irrigation programmes as part of overall national development plans. Irrigation became an important component of agricultural development schemes and often a dominant one because of the huge financial outlays it required in comparison with other components. It is estimated that government programmes implemented so far cover about 90 percent of the irrigated area in Thailand and Malaysia, and 80 percent in Indonesia and the Philippines.

Irrigation development in these countries aims primarily at achieving food self sufficiency. In Thailand the export of rice is an additional objective. Financing of irrigation construction is usually arranged through a mix of foreign loans and domestic funds. Invariably, implementation is undertaken by the government irrigation agency but other government agencies usually provide assistance through coordinating committees. These have been established at both national and local levels for the purpose of preparing production plans and targets and coordinating the supply of irrigation water, credit,

fertilizer, seeds, agro-chemicals and agricultural extension services. On the whole, farmers do not participate in the planning and construction of projects. Exceptions are communal irrigation projects and pilot national systems in the Philippines and some projects in Indonesia and Thailand.

Initially there was a preference for large projects because of greater visibility, perceived economies of scale, and expected greater impact on production and overall benefits. Lately, however, there has been a shift in programmes to medium and small scale projects, and from new construction to rehabilitation and improvement of existing systems, as these latter require less funding and can generate benefits in a shorter time.

### I.3 Scheme Development

Irrigation systems vary from a few hectares to over 100 000 hectares. Most of the systems are gravity-fed from rivers and streams with low diversion dams. In some large systems multipurpose storage reservoirs have been constructed for providing year-round irrigation and generating power. There are many systems, however, without storage dams, depending only on the run of the river. In these systems the areas irrigated during the dry season are often less than half of those during the wet season. Because of their much higher cost of operation, pumping systems do not widely occur and they are usually small, low-lift surface water or shallow well pumps which are privately owned and installed where gravity-fed schemes are not feasible.

A project is considered to come to an end at the completion of the planned physical facilities. Foreign financing ceases and the project is handed to operation and maintenance units. Except for small-scale communal irrigation systems assisted by the government in the Philippines and Thailand, the projects constructed by the governments are operated and maintained by their irrigation agencies. All operation and maintenance costs are borne by the government. In Thailand these costs are not recovered from the water users as no water charges are levied on the farmers. In Malaysia, except in the Muda Irrigation Project, there is a nominal irrigation fee of about US$2.40 a year which, however, is too small to cover the costs of operation and maintenance. In Indonesia a tax called "ipeda" is levied on the land which is partly used for that purpose. In Thailand and Indonesia legislation has been passed authorizing the governments to charge irrigation fees but this legislation has not yet been enforced. Farmers groups are supposed to operate and maintain the farm level system consisting of the farm ditches from the government outlet or turnout to individual farmers fields, while the government agency operates the main system and delivers water to farmers groups at the turnout. The government irrigation agencies have programmes to organize water users groups by turnouts to enable farmers to carry out their responsibilities at the farm level. Except in some places where improved strategies have been employed these programmes have not been successful.

## II. BENEFITS OF IRRIGATION DEVELOPMENT PROGRAMMES

Though the irrigation development projects have not yet reached a stage of full maturity, and much remains to be achieved, their beneficial impact, on the whole, is already substantial. In the construction phase, the programmes yielded increased employment and business activity in the project area. Paddy yields and cropping intensities have increased. Before irrigation the paddy lands were productive only during the wet season, averaging in the four countries only 1.5 tons to 2.0 tons per hectare in one year. The introduction of dependable irrigation water supplies considerably reduced the risks of agricultural production and farmers began to invest in fertilizers, high yielding seeds, agrochemicals and improved cultivation practices. Yields increased from 3.5 tons to 4.0 tons per hectare twice a year, especially in the systems served by storage reservoirs.

The introduction of improved irrigation has generated additional activities and benefits. Examples are:

- Demonstration activities in the Upper Pampanga River Integrated Irrigation System (Philippines) on rice-based farming systems featuring crop diversification, as well as poultry, livestock and fish production within the service area of the irrigation systems.

- Promotion of fish culture and dry season crop diversification by the Ministry of Agriculture of Indonesia in irrigated areas of Java and Sumatra.

- Use of irrigation water from small reservoirs in Northeastern Thailand for domestic and livestock use, as well as for the production of maize, soybeans, mungbean and peanuts during the dry season.

- Fish production in irrigation reservoirs, such as the Magat and Pantabangan Reservoirs in the Philippines, which now meet the fish requirements of nearby towns.

- Additional incomes for many farmers in the four countries through duck raising near irrigation canals and the construction of fish ponds that are supplied with water from the irrigation system.

The year-round agricultural activities resulted in increased rural employment. The improved cultural practices required more farm labour for better land preparation, improved methods of paddy transplantation, fertilizer application and proper care of the crop. Moreover, the increased harvests required more labour for harvesting, threshing, transporting and storage of the farm produce.

General business activity increased with the advent of the irrigation systems. The high agricultural activity generated increased services to the farmers. Banks providing credit to the farmers expanded their operations. Both government and private agencies, dealing with fertilizers, agrochemicals and high yielding seeds had to handle more business and employ more people. The urge to improve the production process encouraged the establishment of shops for the manufacture of small farm machinery. The higher production of paddy increased the activities in the storage, milling, transportation and marketing of rice.

Invariably, the irrigation projects had road components in their schemes. In addition to facilitating the transport of supplies and agricultural products, these served to increase communication and social interaction among the villages in the project area. The roads also made more easily available the various services needed by the farmer and his family such as agricultural extension, health and education.

Some projects have storage reservoirs with multiple uses. Apart from making year-round irrigation available, the storage dams of these reservoirs have generated power and mitigated the effects of flooding of the lower areas. The hydropower generation has conserved foreign exchange (oil import) and has furnished electric energy to households, industries, and commercial enterprises not only in the project area but even far beyond. The storage reservoirs have also provided for recreation, fish production, and conservation of wildlife.

Some improvements in the material life of the people and the communities are noticeable. In many places the quality of housing has improved from light to stronger materials. Stores selling consumer goods have increased. Many farming households have acquired electrical appliances and television antennaes have sprouted from their rooftops.

Principal beneficiaries have been the governments themselves. In the Philippines and Indonesia the increased paddy production made the two countries self-sufficient in rice, the principal staple, despite the yearly increases in population. Thailand has always been a rice exporter and its irrigation programme has further bolstered its position in this regard. Malaysia is still importing some rice as the area devoted to paddy (in relation to population) is small compared to the other three countries. However, its irrigation agency has rice self-sufficiency as one of its major objectives.

While substantial benefits have been obtained from the irrigation programme in the four countries much remains to be realized: the benefits of dependable irrigation have not yet reached many target areas in most of the irrigation projects. Questions are being asked why this is so, and efforts are being made to find the roots of the problems.

## III. EXPERIENCE GAINED

The constraints to irrigation development may be broadly grouped into:

- constraints in planning and construction of new irrigation systems;
- constraints in improving existing irrigation systems and their performance.

Improvement of existing systems is considered necessary since many irrigation systems in the four countries are performing well below their potential. The high cost of constructing new systems and the difficulty of raising funds have recently caused an increased preference for rehabilitation programmes. Rehabilitation requires, however, that the institutional policies and management practices be improved along with the physical facilities. Limiting rehabilitation to these facilities only is unlikely to have a significant impact.

### III.1 Farmers' Participation

Participation of the farmers is a key factor in the successful development of irrigation. While there are significant areas with a high degree of participation, these are still only a small fraction of the total area of all the irrigation systems in the four countries. Obviously, participation of farmers by itself does not remedy poor irrigation performance. There are other components that must be combined with participation, such as capability building of farmers and their irrigation associations, development of proper attitudes of government irrigation personnel, adoption of appropriate policies by the irrigation agency, etc. Participation is, however, the key to attaining sustained performance improvement because the government by itself cannot handle all the tasks of irrigation development. Moreover, it facilitates the solution of other constraints.

During planning and construction, lack of participation of the farmers usually results in location of canals and structures which do not correspond with farmers' needs. Consequently, farmers do not use those facilities and sometimes even destroy them. Lack of participation of the water users further results in a host of problems during the post-construction stage, such as inequitable water distribution, wastage of water at the farm level, and poor maintenance of the system. Increased participation would facilitate the mobilization of labour or the constitution of funds for the maintenance of canals that cannot be undertaken by the government due to lack of funds. Although farmers' participation may considerably reduce the maintenance problem, it may also facilitate agricultural practices, agreed irrigation schedules, and a feedback of field problems to the agency operating the main system, with the result that water deliveries would be more effective and cropping intensities would increase.

The lack of appropriate methods and policies for motivating and training farmers in effective participation in irrigation development and management poses a basic problem. Successful methods and policies to maximize farmers' participation in planning, construction and operation and maintenance of irrigation systems have been developed in the Philippines. However, these are recent developments and, furthermore, these methodologies have to be understood, tested, and probably modified to suit the conditions of the other countries. Their application will require interdisciplinary processes, appropriate policies, and unwavering support from the highest level of the irrigation agency.

But government irrigation agencies initially tend to resist the idea of farmers' participation because it is believed that such participation will delay project completion. Projects in the Philippines, however, indicate that properly planned and implemented farmers' participation, while initially difficult, facilitates many aspects of project implementation and does not need to delay project completion.

Farmers' participation helps to avoid hasty planning and implementation of projects. It requires close coordination among technical personnel and staff assisting the farmers, dedication on the part of government personnel working with farmers, and new attitudes and procedures on how to assist farmers. Thus, reorientation and retraining of the bureaucracy is almost always needed to improve the agency's capacity to respond properly to farmers' participation.

### III.2 Operation and Maintenance Funding

The most obvious constraint to better irrigation performance in the four countries is the lack of funds and resources for proper operation and maintenance of the irrigation systems. This has resulted in inadequate personnel, inequitable water distribution, poor maintenance, system deterioration and a progressive loss of system capacity. In government operated systems in Indonesia, Thailand and Malaysia, operation and maintenance funds are appropriated annually as a subsidy by the government. Generally however, the appropriation is much less than what is required. Furthermore the available funds have tended to decrease on a per hectare basis as additional irrigation projects reach the operational stage.

In irrigation systems operated by farmers' groups, the lack of resources for adequate operation and maintenance is associated with poor organization and lack of viability of the water users association caused by any or a combination of the following:

- Ineffective processes for organizing water users.
- Defective irrigation system planning and construction.
- Limited capacity of the water users association to manage the system effectively for equitable water distribution, conflict resolution and system maintenance.
- Difficulty of mobilizing contributions in cash or labour from association members.

Recovery of operation and maintenance cost from the farmers is at present only very partially achieved (para 8). In the Philippines, where the cost of national irrigation systems is no longer subsidized by the government, the irrigation agency collects less than 65% of its annual billings for irrigation fees. Major causes of low irrigation fee collections, especially in the larger systems, include:

- Dissatisfaction of many water users with the adequacy and timing of water deliveries due to any or a combination of the following: i) interference with water distribution by other farmers especially at night, ii) water shortage due to either lack of water at the source or faulty distribution, iii) defective or inadequate distribution structures, iv) poor maintenance and general deterioration of facilities.
- Low paying capacity of water users due to any or a combination of the following: i) low price of paddy compared to production costs, ii) low yields, iii) debts for lease of the land and interest on loans, iv) crop damage.

The relatively low paddy price tends to discourage farmers' efforts to attain higher yields per hectare. However, it has not discouraged the Philippine government from constructing new irrigation systems or rehabilitating and improving old systems. In Thailand, Indonesia and Malaysia, where the operation and maintenance costs of most systems are borne by the government, there are no indications that the low price of paddy has affected the efficiencies of irrigation systems. As in the Philippines, however, it has tended to discourage higher per hectare yields.

### III.3 Cropping Calendar

In the government operated systems, a cropping calendar is usually prepared for optimizing water use and increasing the cropping intensity of the system. The implementation of the calendar always gives rise to problems, the magnitude of which increases with the size of the irrigation system. The cropping calendar is communicated to all water users who are informed that water releases will be in accordance with the calendar. But in many cases farmers cannot adhere to the schedules due to delays in acquisition of credit, seeds and fertilizer, or to the lack of farm animals needed for cultivation. The delays in the agricultural inputs sometimes stem from the support agencies that make them available

to the farmer. But more often they are due to outstanding loans that have to be settled by the farmers before they can become eligible for new loans. The resulting delays in cultivation and planting have two adverse effects.

- Where delays are numerous there is difficulty in communicating the actual situation to the operating agency thus resulting in water deliveries at places which are not ready for using the water.

- The cropping calendar is stretched and the cropping intensity of the system is reduced.

III.4 **Training**

A further constraint is the lack of incentives and appropriate training for irrigation systems operation and maintenance personnel. Traditionally, because of the design and construction orientation of irrigation agencies, the staff of operation and maintenance has been considered as having a lower status compared to that in the other engineering activities. This has tended to lure the best personnel away from operation and maintenance activities. Furthermore no appropriate capacity building programme is yet fully available for operation and maintenance personnel. There are training programmes on soil-water relationships, water requirements, water allocation and scheduling, and maintenance procedures, but there is very little on effective ways of addressing institutional problems, especially on ways to generate farmers' participation and organize effective and viable water users associations. As a result engineers and other operation and maintenance personnel have skills only in the technical aspects of irrigation. What they need in addition is appropriate orientation and training in the institutional aspects.

III.5 **Irrigation Scheme Funding**

A problem that has arisen in varying degrees in the four countries during the last few years is the lack of domestic funds for constructing new irrigation systems. The major irrigation projects, whether completed or on-going, in these countries are funded by loans from foreign financing institutions and local counterpart funds. In addition to problems associated with the growing debt burden there are difficulties in generating sufficient counterpart funds for on-going projects. The lack of counterpart funds has delayed the completion of many projects.

III.6 **Social and Cultural Environment**

Irrigation is basically a cooperative undertaking as it involves the sharing of a limited resource among numerous users. Thus social and cultural factors influence the performance of irrigation systems. The successful systems in Southeast Asia indicate that better irrigation system performance (in the sense of adequate operation and maintenance through many years, better equity in benefits, and more effective resolution of conflicts) is found where there are:

- Greater social homogeneity: no wide social gaps that prevent communication and interaction among the members of the community.

- Relatively small landholdings that require intensive agriculture.

- Availability of strong leadership responsive to the needs of the community and free from partisan politics, and

- A community without cultural impediment to change.

Thus, social and cultural factors should be considered in planning irrigation systems. They should likewise be considered when an irrigation agency attempts to improve irrigation systems that are operated by farmers groups. Each of these systems has its own social organization based on the layout of its canals in relation to the ownership pattern of the irrigated land. Any change in the location of existing canals or distribution structures entails changes in the organization of the water users that often pose difficult problems.

III.7 **Water Management**

During the past decade, in government operated systems in the four countries, water management improvement was essentially based on the concept that the operation and maintenance of the main irrigation system was the responsibility of the government, while the farm level systems below the turnout were the responsibility of the group of farmers being served from the turnout. This arrangement entails an expeditious, dependable way of transmitting information from the irrigation agency to the farmers. It also results in a reliable feedback from the farmers to the irrigation agency. Programmes have been launched to organize farmers in each turnout more specifically with a view to facilitating the communication process and the coordination between the management of the main system and the farm level system. These programmes have had little success: farmers appear to perceive these programmes as serving the interest of the government agency rather than theirs. However, new participatory approaches have recently been developed in the Philippines which have shown encouraging results. These new approaches are now being tried out with modifications in some irrigation systems in Indonesia and Thailand.

**IV. RECOMMENDATIONS**

In irrigation systems which the government has to operate and maintain, an appropriate level of irrigation fees to be paid by the water users should be established to lighten the burden of the government. Experience in the four countries shows that governments are unable to allocate enough funds to cover the recurrent cost of the systems. Payment of irrigation fees is a form of participation in the operation of the system. Where farmers have sufficient paying capacity they often prefer to pay irrigation fees instead of contributing labour and materials directly. Collection of the fees should be undertaken by the agency managing the system. Penalties should be imposed for failure to pay the fees. Experience in the Philippines indicates that enforcement through group pressure and social sanctions by members of well organized irrigation associations is more effective than legal action by the government.

The farmers-water users should participate in irrigation development. Participation should begin in the planning stage of the project. It requires that the farmers be well organized. The organizing process should be developed and tested in pilot projects. The use of catalyzing agents should be explored. The catalyzing strategy should be designed around issues and activities meaningful to the farmers. Opportunities should be made available to farmers to participate in problem solving and decision making during the organizing process. The processes being used in the pilot projects should be documented and analyzed for further improvement. It would be advisable to have an interdisciplinary group, consisting of members skilled in engineering, agriculture, management, sociology, economics and training, assist the pilot project in planning interventions, analyzing results, and designing improvements.

It is essential that the technical activities in the construction of an irrigation system and the organization of the farmers to participate in the development and management of the system be undertaken by the same agency. These activities are intertwined and tight coordination between technical activities and organizing work is extremely important.

As the pilot studies are being conducted, the irrigation agency should develop its capacity to respond positively to farmers' participation. This will require specially trained personnel and adjustments of policies and procedures that inhibit farmers' participation. It will also require reorientation of attitudes and perceptions of agency staff. Developing that capacity takes time. The training as well as the training materials and processes should be based on the experience gained in the pilot projects. The capacity building in the agency should be interdisciplinary and should employ a learning process approach.

The pilot projects and the initial application of results should be directed and actively supported by the highest level of the agency. When the agency has built an adequate capacity its approaches and processes should become a part of the operating procedures of the agency.

Sufficient resources should be made available by governments to cover the recurrent cost of the systems. A newly completed system needs a period of development during which its efficiency is gradually improved. This process always requires funding for training activities and additional structures, or modification of existing structures, over and beyond the requirements of normal operation and maintenance.

Caution should be exercised in predicting benefits that will accrue to farmers in areas where there are no clear titles to ownership or where the incidence of tenancy is high. One of the reasons for low paddy production per hectare in Thailand appears to be the general lack of clear titles to the land. Likewise, paddy production in the Philippines is generally low in areas where there is a high incidence of tenancy.

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ANNEX 1

**Government Policies on Scheme Operation and Maintenance in Indonesia, Thailand, the Philippines and Malaysia**

**I. INDONESIA**

Irrigation systems are classified by the government in four categories: "technical", "semi-technical", "simple" or "sederhana", and "village". The first three are constructed and managed by the government, while the fourth (village irrigation) is constructed and managed by farmers' groups. "Simple" or "sederhana" systems are those that do not exceed 2,000 hectares selected by the government according to standard criteria, generally without an economic feasibility study. Designs are simple so they may be easily constructed using labour intensive methods. When government decides to include a village irrigation system in its improvement programme, it becomes a sederhana system. "Technical" and "semi'technical" systems are larger systems subjected to more rigorous feasibility studies and technical requirements. In all the systems constructed by the government the general policy is to construct only the main system and leave the farm level system as the responsibility of the farmers. In most cases, however, there is a deviation from this policy, as farmers do not accept this responsibility. The government, then, has to construct also the farm level system.

When the construction is completed, the central government transfers the irrigation system to the provincial government for operation and maintenance. The general policy is that the provincial government, i.e. the irrigation division of the provincial public works office, operates and maintains the main system and delivers water to farmers' groups. The farmers are expected to operate and maintain the farm level system. The provincial agricultural extension office has the responsibility of assisting the farmers in water management and crop production.

Except in the Balinese irrigation system, the farm level responsibility for operation and maintenance is placed on the village chief who appoints a village watermaster to attend to water distribution and to mobilize farmers for maintenance work. Cropping calendars are prepared by provincial agricultural committees and disseminated to water users. In some areas water users associations called P3As have been organized. These are informal village-based groups without legal status.

The arrangements on the island of Bali where about 1300 "subak" irrigation systems irrigate about 100,000 hectares are different. Water users are organized in the subak on the basis of common access to a water source. The boundary of the subak is completely independent from the village administration. Its basis is the Hindu Balinese religion. Membership of all water users is compulsory. Elaborate rules to attain equity of water distribution in times of water shortage are strictly observed.

No irrigation fees are collected from the water users. The law considers water as a gift of God which cannot be charged. But fees can be charged for delivering water and the government is now planning to impose irrigation fees. At present a land tax called "ipeda" is levied by the provincial governments and a small part of it is spent for operation and maintenance of the systems. As this is very inadequate the central government gives a subsidy to the provincial governments. However, this subsidy is limited and, as a consequence, the funds available are always insufficient for the operation and maintenance of the main system.

Indonesian irrigation agencies are in search of better ways of organizing water users to improve feedback from the farmers to the agencies. They feel that the subak cannot be reproduced elsewhere in Indonesia due to its religious basis. Thus they are exploring other approaches and have established a number of pilot projects in Java and Sumatra, with assistance from the Ford Foundation and USAID, for developing farmers' participation in irrigation development.

## II. THAILAND

Irrigation systems in Thailand may be classified into two general categories: government irrigation systems and people's irrigation systems. The former are systems constructed and managed by the government under its Royal Irrigation Department (RID), while the latter are constructed and managed by farmers with the assistance of the government. Government systems are usually large and medium scale projects built for increasing rice production to stabilize the domestic price of paddy and to enable Thailand to maintain its rice export position. People's irrigation systems are mostly small scale and are rehabilitated or improved by the government to assist small farmers. A previous policy for the government systems was to construct only the main system in the expectation that farmers would construct the tertiary canals. As farmers have not done so the RID has revised its policy and is now constructing terminal facilities. It has even undertaken a land consolidation project.

The RID has given some attention to the improvement of people's irrigation systems most of which were built several hundred years ago. It is estimated that these cover about 300 000 hectares with many individual systems larger than 700 hectares. To divert water to their paddy fields, farmers built low dams (up to 3 metres high) with logs, bamboo and stones. In each of these systems farmers have regulations for water distribution, maintenance and repair and they contribute funds to pay people for managing the system. Thus the government does not have any operation and maintenance problem. For these systems government assistance usually consists of the construction of permanent dams and other structures for water control and distribution.

In government irrigation systems the main system is managed by the Royal Irrigation Department. Farmers' groups receive water at the turnout and manage the farm level system. To promote agricultural production, coordinating committees composed of representatives of different agencies of the Ministry of Agriculture and Crops are usually established at the provincial and project levels. The RID has been organizing farmers below the turnout level to improve water management but it has not yet achieved significant success. Research has commenced in Northeastern Thailand on how to use the experience in the people's irrigation systems for organizing farmers in the government systems. Assistance to farmers in water management is jointly undertaken by the RID and the Department of Agricultural Extension.

At present farmers in Thailand do not have to pay irrigation fees. Instead, the government imposes a tax or premium on rice exportation to generate government revenues. Notwithstanding this, the funds which the government allocates to RID are not sufficient for satisfactory operation and maintenance. Therefore, plans are now being considered to charge irrigation fees to farmers.

## III. PHILIPPINES

In terms of ownership, irrigation systems are classified into national, communal or private. National irrigation systems are owned, constructed and managed by the government through the National Irrigation Administration (NIA), a government corporate agency. Communal irrigation systems are owned and managed by farmers' irrigation associations.

They are either systems constructed by farmers' associations or constructed by NIA and turned over to irrigation associations which are registered with the government and empowered to undertake business. Private systems are those constructed and managed by an individual to irrigate his land and sometimes that of a few neighbours. Of the total 1.35 million hectares irrigated, about 500 000 hectares are in national systems, 600 000 hectares in communals and 250 000 hectares in private irrigation systems.

In the Philippines all waters belong to the State. Any entity, including government agencies, requiring water for any use, needs a water permit that stipulates the amount, purpose and period of use. In national irrigation systems the general policy is that NIA manages the main system and delivers water to farmers at the turnout. The farmers are responsible for the farm level system. There is also a parallel policy for NIA to turn over operation and maintenance of the main system or any part thereof to duly organized irrigation associations based on mutual agreement. NIA has turned over a number of small national systems to farmers' associations for joint operation and maintenance of the main system. NIA trains irrigation associations in both national systems and communal systems in water management. Assistance in crop production is given by the Ministry of Agriculture.

The operation and maintenance of communal systems is not a burden to the government as it is undertaken by farmers' irrigation associations. NIA, however, has extended assistance to many communal systems in the form of improvements of irrigation facilities, generally permanent dams and improved distribution systems. The irrigation associations repay the cost of these facilities without interest. The minimum annual payment is the cash equivalent of 75 kg. of paddy per hectare of land irrigated by the improved system (until the cost of construction is fully paid). Many of these systems were in existence before the government started its communal irrigation development programme. Most notable of these are the "zangeras" of Northern Luzon which have elaborate regulations strictly followed by its members for land and water distribution as well as for maintenance of facilities.

Irrigation fees are charged to all irrigation systems constructed by the government in accordance with the policy that the level of fees should be sufficient to cover costs of operation and maintenance and the repayment of cost of construction of the irrigation system, without interest and within a period of not more than fifty years. However, the level of the fees should not be a disincentive to production and should be within the paying capacity of the farmers. The cost of construction to be repaid through irrigation fees applies to irrigation facilities only and does not include roads, flood control, power and reforestation. Before the adoption of this policy, the operation and maintenance of national systems was partially subsidized by the government. This subsidy has now been phased out and NIA operates and maintains the national irrigation systems from its irrigation fee collections.

## IV. MALAYSIA

Compared to the other three countries, Malaysia has the smallest irrigated area: about 370 000 hectares, mostly in paddy, of which about 245 000 hectares is double-cropped. As in the other countries irrigation development started more than 200 years ago with farmer constructed temporary diversion dams. Government efforts since the 1930s have transformed almost all of these systems into government schemes in which the Irrigation and Drainage Department (DID) of the Ministry of Agriculture operates and maintains the main system while farmers look after the farm-level system.

Planning and construction is undertaken by the federal government with some foreign loans in the case of the large systems. Upon completion the systems are turned over to the state governments for operation and maintenance. Each state charges annual irrigation fees of about six Malaysian dollars (US$ 2.40), except in the Muda Irrigation System where it is about 100 Malaysian dollars (US$ 40) per year. Malaysia still imports ten to fifteen percent of its rice needs. The objective of irrigation development is increasing the productivity of existing irrigated areas, as there is little remaining land that can be economically converted to paddy. Attention is now being given to the improvement of farm level irrigation facilities which will permit farm mechanization.

An exception to the usual arrangements for irrigation in Malaysia is the Muda Irrigation System which is being managed by the Muda Agricultural Development Authority. In this system, which serves 96 000 hectares, the irrigation, agricultural, and institutional activities are integrated under one agency. For every 4000 hectares, farmers are organized into a Farmers' Association (FA) and a Farmers' Development Center (FDC) is constructed for the area. The FA serves only its members, but the FDC is for all farmers whether or not they are members of the FA. Every FA is divided into Small Agricultural Units (SAUs) each of which cover one or more villages. Membership in the SAU is based on residence in the village. However, difficulties arise because not all farmers in a village farm in the same locality. Modifications have therefore been introduced to convert the SAUs from village based organizations to canal based organizations. The membership of these is determined by a common source of water supply in the irrigation system.

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ANNEX 2

## The Philippine Experience and Strategies in Water Users' Participation

The Philippine experience in developing participatory approaches and institutionalizing them in the National Irrigation Administration (NIA) includes a learning process over a period of seven years. It started in 1976 with two pilot projects in the communal irrigation programme. The processes were refined in 1979 in other pilot projects. In 1980 twelve additional pilot projects were used, one in each region of the country. A year later pilot communal irrigation projects commenced in all eighty-six provinces covered by the NIA and the participatory approach was tried in one pilot national irrigation project and later in other national systems. It is now used by the NIA in all its communal irrigation projects and in 28 small national systems covering about 26 000 hectares.

The NIA process of organizing farmers into irrigation associations is based on progressive development of farmers' capability to work together, identify effective leaders, and solve problems through participation in the planning, construction and operation and maintenance of their system. This is done by a trained community organizer (CO) using tested social processes of integration with the community, groundworking, mobilization and action reflection. In the process, the farmers develop a feeling of ownership of the irrigation system and a willingness to take responsibility. The CO is fielded in the service area 8 or 9 months before construction and lives in the area throughout the planning, construction and the initial year of operation. The CO acts as a catalyzer in analysing, persuading, arguing, and challenging, but he never takes away the decision making from the farmers nor performs the tasks which the farmers themselves should undertake. Assisted by the CO, farmers formulate by-laws for their association and register their association with the government to obtain legal status. The association secures a water permit from the government to appropriate water for irrigation and distribute it to its members.

When the construction is nearing completion, NIA gives the association training in irrigation systems management and in financial management. A new approach to training in irrigation systems management has been developed under the programme. Instead of giving the association a ready made management plan prepared by NIA and training the association in the implementation of the plan, the new approach gives the association a process for developing their own plan. The process consists of modules on cropping calendar, normal water distribution crisis water management, conflict management, farm level facilities, maintenance, and general rules and regulations. Thus the association develops a capacity not only in preparing their plan but also in improving it at later stages. When the project is completed and the association has taken responsibility for its management, NIA continues to extend technical assistance and guidance as needed. After two seasons the CO moves to a new irrigation project. Further follow-up work on the irrigation system is

undertaken by an irrigation technician of the NIA and agricultural extension workers of the Ministry of Agriculture. The CO may be called to assist as may be needed.

The participatory approach programme of NIA in its communal and national irrigation systems has yielded benefits both to NIA and the farmers. In the communal systems these are the following:

- Ready acceptance for operation and maintenance by the farmers of completed physical facilities as well as their obligations for repaying chargeable costs. Projects completed prior to the programme experienced difficulties in being accepted by the farmers, often because of disagreements on costs to be repaid.

- Increased counterpart contributions from the farmers. In 1982, the total counterpart contribution by farmers in projects covered by the programme amounted to ₱2.7 million. It increased to ₱4.9 million in 1983. Prior to the start of the programme counterpart contributions were almost negligible.

- Improved maintenance of canals and higher irrigation fee contributions have been observed in the communal systems which have completed their system management and financial management workshops. No data is yet available on equity of water distribution, increases in irrigated area, and increases in production as evaluation studies have just been started. However, the increased irrigtion contribution indicates an increase in farmer satisfaction with the system.

- Increased awareness with engineers and other technical staff of the institutional factors that affect irrigation development.

- Greater cohesion among the farmers in the form of a stronger association and greater capability of the farmers to manage their affairs.

Similar results have been obtained in the pilot national systems:

- In the pilot participatory projects there has been no removal of farm ditches by farmers after construction. In previous projects where farmers did not participate, many complaints on farm ditch locations were experienced, and the farmers eventually removed the ditches.

- Prior to the programme, NIA had been using the farmers to assume operational responsibilities without results. In contrast, in the pilot participatory projects the farmers initiated and pursued active negotiations with NIA to turn over to them all or part of the system for operation and maintenance. At present eight small national systems with a total area of 3400 hectares have been turned over to the associations. Irrigation associations have also taken over responsibilities, including the collection of fees, in a total area of 13 000 hectares in ten other national irrigation systems.

- In these areas canal maintenance has improved, rules are more effectively enforced, irrigation fee collections have increased, and NIA expenses for O&M have decreased so that collections now exceed expenses.

- A few irrigation associations have reported some increase in irrigated areas. More data is being gathered on this and on the equity of water distribution.

In the course of its participatory approach programme, NIA encountered the need for interdisciplinary research in irrigation development. Under the programme, NIA research focused on interdisciplinary processes for addressing institutional development, problems of irrigation organization and management practices in existing irrigation systems, performance of irrigation personnel, and financial management of successful communal systems. Action research was initiated consisting of documentation of the processes used in the programme and monthly discussions of the documentation reports by an interdisciplinary committee. This committee was composed of volunteers from other institutions interested in the NIA programme such as the Asian Institute of Management, the International Rice Research Institute and the Institute of Philippine Culture.

REFERENCES


1. Thailand Agricultural Project Identification Report. June. IFAD, Rome. 1984.

2. Apinantara A. Socio-economic and Organizational Factors Affecting Water Users Association and Effectiveness of Water Utilization in Northern Thailand. Khon Kaen University. 1983.

3. Development and Improvement of Subak Irrigation System in Bali - Conference on Organization as a Strategic Resource in Irrigation Development. Manila. November. 1982.

4. Irrigation in Indonesia. Expert Group Meeting on Measures to Improve the Performance of Irrigation Projects. Bangkok. June. 1981.

5. Bagadion B.U. Water User Organizational Needs and Alternatives. Regional Symposium on Water Resources Policy, Dhaka. August. 1985.

6. Bagadion B.U. Farmers' Involvement in Irrigation Development in the Philippines. Expert Consultation on Irrigation Water Management, Yogyakarta and Bali. July. 1984.

7. Framji K.K., Garg B.C. and Luthra S.D. Irrigation and Drainage in the World. Vol. II.

8. Thavaraj S.H. Management of Irrigation Projects - The Link between Engineering Concepts and Institution Building. ICID Second Regional Afro-Asian Conference, Manila. December. 1978.

9. International Commission on Irrigation and Drainage, New Delhi. 1982.

Doc. III-B (1)
(Original in English)

# MANPOWER AND TRAINING NEEDS FOR IRRIGATION IN AFRICA

SUMMARY

VI. CASE STUDIES - NIGERIA, TANZANIA AND ZIMBABWE



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**SUMMARY**

The lack of suitably trained manpower forms one of the major constraints to irrigation development and operation in the Region. An analysis of manpower needs and training requirements is essential, and despite a severe lack of readily available data, such an approach is both possible and effective.

Six issues are of particular importance in determining manpower and training needs:

- Government policy in relation to irrigation
- The role of farmers
- The tasks of irrigation manpower
- Staffing levels
- Manpower quality
- Institutional factors

Manpower development is conveniently considered under the headings of **institutional education** (i.e. formal courses leading to qualifications) and **in-service training** (i.e. continuing, on-the-job, strengthening of skills and expertise). Institutional education is often weak on practical and management aspects, and in-service training is rarely well structured and adequately resourced.

The manpower planning process is an analysis of **demand** - based on projected irrigation growth rates and appropriate staffing levels - and **supply** - evaluated by examining the existing irrigation sector and both institutional and in-service training arrangements. Shortfalls in manpower numbers, quality and institutional performance are identified, and a strategy is formulated to meet the needs in an integrated way. This simple approach is complicated by the difficulties in practice of accurately forecasting irrigation growth and by the lack of accepted staffing levels. Implementation of the manpower plan is often difficult **inter alia** because of the degree of coordination required across Government Ministries responsible for agriculture, irrigation, education and national planning.

The manpower needs implied by particular target growth rates are not immediately obvious, and so an illustrative example is included in this paper to highlight these. The example brings out the scale of the problem, as well as exposing the importance of educational lead times and wastage rates. The trained manpower needs must be met by an integrated package of short and long term measures combining institutional education and in-service training. It is important too that the mechanism for continued operation of the manpower plan is instituted.

Case studies from Nigeria, Tanzania and Zimbabwe are used to illustrate the diversity of irrigation policy, practices and manpower needs in the Region.

## I. INTRODUCTION

If irrigation development is to achieve its full potential in Africa, it is essential that its practitioners both possess the appropriate expertise for their tasks and are sufficient in numbers. At the present time however, manpower constraints form one of the greatest limitations to the success of irrigation in the Region, especially south of the Sahara.

Well planned, competently designed and constructed, and adequately managed irrigation schemes do not come about easily. Where they exist, they have been achieved through the skills, knowledge and experience of individuals and organisations. Education and training have provided the basis of this expertise.

There is an urgent need for Governments and Donor Organizations to approach the provision of manpower for irrigation in a planned and logical way. This paper sets out such an approach which takes account of both the training needs of existing staff and the provision of new manpower.

It is important, for two main reasons, to take a long term view of this subject. Firstly, the education and training, particularly of senior project staff, takes a very long time. A university place has to be available now to provide a project manager in 10-15 year's time (more than one place when manpower losses are taken into account). Secondly, short term provision of training and education carried out largely by external organizations, will fail to develop national capacities to provide manpower. Thus, a continued dependence on external donors will be fostered.

In Africa, most formal irrigation schemes are administered by the Government Ministries or Parastatals with overall responsibilities for scheme operation. This means that they usually employ both engineering and agricultural personnel. "Operation and Maintenance" therefore, in the African context, includes both main system management and field level soil, crop, and water management. The role of the farmers on formal irrigation schemes is critical, since it determines both the staffing needed for operation and maintenance and the extension role which operation and maintenance staff must have.

In informal irrigation, an area which is currently receiving increasing attention, there is a need for agricultural extension staff to have some knowledge of irrigation. This will imply the need for a number of subject specialists, and a more general awareness of irrigation by all agricultural staff.

## II. MAJOR ISSUES

Six important general issues are considered here as a background to manpower planning and training needs assessment:

### II.1 Government Policy

This will determine not only the priority given to irrigation in the national economy, but also the importance given to different approaches and the rate at which such developments will take place. It is important that these three aspects are made as explicit as possible to enable manpower planning to take place against a known policy background.

### II.2 The Role of Farmers

One aspect of irrigation policy and practice which is particularly important is the role of farmers on the formal smallholder irrigation schemes. The degree to which they take responsibility for water management, maintenance and agricultural operations determines the roles and consequently the numbers of the engineering and agricultural staff employed in "operation and maintenance."

In those cases where farmers' roles are rather limited in the early stages of scheme development, it will be the intention to gradually hand over responsibilities to them. This implies that the operation and maintenance staff have a significant training

role, and they themselves therefore must possess communication skills.

### 11.3 The Tasks of Irrigation Manpower

Irrigation manpower in this context refers to individuals who are required to work in either the engineering, agricultural, or management aspects of irrigation development and management, and who consequently require education and training in the various aspects of irrigation. Support personnel such as craftsmen, mechanical technicians and non specialist civil engineers are not included here.

In common with general practice, this paper refers to staff at three levels:

Professional - generally holding a university degree or postgraduate qualification.

Technician - holding a technical qualification, usually a two year diploma, with perhaps an additional two year higher diploma.

Vocational - having completed primary schooling followed by a one or two year Certificate course (this category is not recognised in all African countries).

The roles and tasks of irrigation manpower vary widely, depending on the type of scheme in question. Their general education has therefore to prepare them for a wide range of possible roles.

Generally, professional level staff must be prepared to take responsible positions in resource surveys, scheme planning and design, construction supervision and scheme management. A professional engineer or agriculturalist on a very large formal irrigation scheme might be in charge of 5-10,000 ha, under a professional project manager with 10-15 years experience. Professional staff, depending on their particular roles, might supervise 5-7 technicians.

Professional level staff generally refers to staff qualified in engineering or agriculture. Ideally, it is a combination of the two, provided by agricultural engineering institutions with a focus on soil and water engineering, or "Genie Rural" (Francophone countries).

Technician level manpower should generally be equipped to carry out relatively complex technical tasks with minimum supervision, including for example, topographic and cadastral surveys, agronomic and water management, data collection, monitoring of soils, water and crops, etc. A technician may receive support from 3-5 vocational level staff who would be qualified to assist with technical tasks under instruction and supervision.

In the case of agricultural staff especially (where such a separate cadre exists), there is a significant extension role to fulfill.

In view of their supervisory and liaison roles, technicians and professional level staff can benefit greatly from an awareness of organisational and personnel management dynamics. This is particularly the case when there is a need for inter-departmental coordination between, for instance, engineering, agricultural mechanisation and other staff.

### 11.4 Numbers Required

There is little doubt that African irrigation could be made to function more effectively if efforts were concentrated on making better use of existing manpower. This is considered in Section 11.5 and 11.6.

It is nevertheless still important to analyse rationally the numerical requirements for existing and planned irrigation developments. Before this can be done, it is necessary to identify the specific roles and organisational structures appropriate to the different aspects of the irrigation sector (e.g. planning and design, formal scheme operation and maintenance, informal irrigation support, research, and education and training). Having

done this, numerical values or staffing levels can be developed, preferably from experience gained in regions which share similar irrigation schemes, agro-ecology, and social, political and economic environments.

There is little published information on irrigation staffing levels, and that which exists is of very limited use because of different educational standards and nomenclature. The data which are available show extremely wide variations in staffing levels from one country to another.

Two general points can be made however:

- the numerical staffing requirements for feasibility studies, design, construction supervision and research are relatively low. It has been estimated, for example, that for the planning, design and preparation of contract documents for the development of 1.4 m ha of formal schemes phased over 25 years in Nigeria, the professional level irrigation manpower needs in post would need to range from 30 initially to a maximum of 120 at peak rate of development;

- the requirements for operation and maintenance staff on formal schemes are numerically the most significant. In the Nigerian case cited above, the developments would imply a total number of irrigation professionals in post by the second decade of the 21st century of 560, assuming presently realistic organisational structures and staff roles. Technician level numbers would be 5-7 times this figure.

In countries lacking a qualified and experienced employment pool, there can be a tendency to overstaff with poorly trained, inexperienced and ill motivated staff. It cannot be over-emphasised that numbers are no substitute for quality and competence, and in fact overstaffing simply causes additional operational problems.

### II.5 Manpower Quality

Manpower quality refers to the abilities and performance of staff in relation to their roles and tasks. Poor performance often arises from inadequately qualified staff rather than from insufficient numbers of staff. Raising the quality of education and training will be a major component of any programme to improve institutional performance.

The subject matter of formal education has already been mentioned (II.3). At professional level, it is especially important that the interdisciplinary nature of irrigation is recognised, and that education includes all relevant aspects of engineering, agriculture, social, economic and management studies.

At all levels, there is a great need for practical and management skills to be emphasised during education. Unfortunately, the educational sector itself often suffers greatly from understaffing, underqualified staff and lack of resources. Consequently, teaching tends to be conventional, theoretical and unconvincing instead of innovative, practical and authoritative. The most important consequence of this is graduates and diplomates who lack confidence, and especially, practical skills.

In view of the extension and training roles filled by many staff, the importance of trainer training is being increasingly recognised.

Clearly, formal educational qualifications cannot meet all the training needs of irrigation manpower. Once in post, it is essential that training continues and leads to technical or professional recognition. This and other aspects of in-service training are further discussed in Chapter III.

### II.6 Institutional Issues

Even given adequate numbers of well trained staff, there are many constraints to their performance, both within and outside the organisations which employ them. Some of these can be ameliorated by appropriate management training.

Aspects which management training can improve include:

- setting and working towards specifc objectives
- supervision and evaluation of staff performance
- motivating and encouraging staff
- coordination between departments
- running meetings and committees

No training, however, can overcome external issues such as inadequate operating budgets, lack of incentives to producers, non-availability of fuel, spare parts, and inputs, and so on.

## III. EDUCATION AND TRAINING

Formal or **institutional education** of one year or longer duration provides the basic knowledge, some practical skills and the qualifications for employment. For staff in post, whether recently qualified or having many years' experience, it is essential that **in-service training** continues to develop their skills.

### III.1 Institutional Education

At professional level, irrigation is usually a specialisation, building on general agricultural, engineering or agricultural engineering subjects taught during the initial part of the college and university programmes. At technician and vocational levels, there is often a greater degree of specialisation in irrigation studies than at undergraduate level.

In the short and medium term it may be necessary to use external educational institutions to help provide qualified professional (and occasionally technical) manpower. Without substantial support to develop national educational capacities, this will remain the case for a considerable time to come.

Training in another developing country for undergraduate or postgraduate qualifications can be attractive. The educational institutions involved may, however, share the same resource problems and theoretical approaches as those in the home country.

Technician, and sometimes professional level, education often includes periods of a few months to a full year of work experience. This is potentially valuable, but its value is often reduced because of a lack of well run irrigation schemes where students can gain sound experience, and because of inadequate work supervision.

At all levels of education, there is a great need for additional practical work and training in management. Practical work does not always require the use of sophisticated laboratories and other facilities. The maximum use should be made of simple equipment, basic techniques and field studies to develop confidence and understanding.

Considerable use should also be made of alternatives to formal lecturing - for example, field visits, work in "live" systems (physical measurements, social surveys, performance evaluation, etc.), laboratory work, seminars and discussions, role playing, simulation exercises, and case studies.

It is essential that educational institutions foster understanding of principles and the ability to think through problems, not merely the mastery of techniques.

### III.2 In-Service Training

It is essential to continue training in a planned and structured way during employment following completion of formal education. National capacities must be developed to provide these types of training, which should include most, if not all of the following elements:

Short courses

These can be held either in the country or in external institutions and have two main purposes. Firstly, they can be used to augment an otherwise incomplete or inadequate formal education. Since these courses should be considered an activity to bridge a period during which formal educational programmes are upgraded, they provide a short-term solution only. Secondly, and properly, short courses can be used to update technical knowledge and skills or to broaden interdisciplinary understanding. Short courses can be as valuable to recent graduates and diplomates as to staff with longer experience.

Professional development

By this is meant individually tailored short programmes of study spent in e.g. educational institutions, private companies, or irrigation schemes. External Universities and technician level Colleges are sometimes able to arrange this sort of programme, but it is generally not yet provided by African educational institutions.

Counterpart training

The appointment of courterpart staff alongside expatriate professionals in externally supported projects is potentially a valuable means of skills transfer. There is a need for increased structuring of such counterpart relationships. National Universities could have a role to play in this.

Professional and technical recognition

Post qualification experience and training at technician and professional level should be structured and assessed to lead to recognition by an appropriate institute. Where this happens, it normally consists (at professional level) of supervised on-the-job experience, professional reports, employers' references and interviews, all carried out over a period of at least five years.

Skills testing

At vocational level, recognition should be achieved through a national practical skills testing system.

Conferences, workshops and meetings

At professional level especially, meetings to present papers, discuss experiences, and share knowledge, can all take a training role. This is particularly so if they have an explicit educative philosophy, and if they lead to the publication of readily available documentation.

Information, materials and resources

The development of knowledge and skills while in post is severely curtailed by the non-availability of journals, manuals, books and equipment (for instance microcomputers). These are essential if staff are to remain up to date in a rapidly changing technical field.

III.3 **Costs of Education and Training**

Indicative costs of certain types of education and training activities are shown in Table 1. The costs in this table represent real unit costs for education and training carried out by or in a European educational institution*. Some comparative unit costs are also given for two educational institutions in West Africa**. Training in another developing country may be a lower cost alternative, but it may not be very cost-effective, if the educational institutions involved share the same resource problems and theoretical approaches as those in the home country.

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**Table 1 - Education and Training Costs (US$ 1984/85) Provided by a European Educational Institution and Two Institutions in West Africa.**

| | | |
|---|---|---|
| 1. | Long course at professional level (BSc, MSc) in UK. (Fees only) | $ 11200 per man year |
| 2. | Long course at professional level in Burkina Faso. | $ 13700 per man year |
| 3. | Long course at higher technician level in Burkina Faso. | $ 10800 per man year |
| 4. | Short course in Europe (2 week course) (fees plus air travel) | $ 945 per man week |
| 5. | Short course in Africa (2 week course) (fees plus local travel) | $ 575 per man week |
| 6. | Individual professional development programme in Europe (fees only, duration from 1 to 52 weeks) | $ 310 per man week |

**Table 2 - Education and Training Projects in Nigeria: Cost Estimates**

| | Project Description | Cost Estimate (US$, 1982) |
|---|---|---|
| 1. | On-project practical and management skills training centre for technical & professional level irrigation manpower (setting up only - recurrent costs not included). | 6.1 m |
| 2. | Management Training Pilot Project - 3 year training scheme for senior management. | 0.75 m |
| 3. | Teaching and Technical Support Staff Development (University and Technician Levels) - pilot project to train teachers and technicians in one Polytechnic over 5 years through link with overseas educational institution. | 2.4 m |
| 4. | University Department Link Project: to strengthen undergraduate and postgraduate output, short course training, and research through 5 year link with overseas university. | 3.6 m |
| 5. | Technician Level Support: improvements to and increases in facilities and output of one technician level educational institution through 5 year link with overseas College. | 3.4 m |
| 6. | Vocational Level Training Institutions: upgrading and enlarging one training school and establishing national skills testing centre (capital costs only). | 1.04 m |

In the long term, it is essential that in-country capability is developed to supply both institutional education and in-service training. Table 2 contains cost estimates of a series of projects designed to meet the training needs of the Nigerian irrigation sector, through development of national capacity.

As a final spproach to the issue of cost, it is estimated that the institutional education alone of the staff required to run a medium sized formal irrigation scheme will have cost about 1.5% of the total capital cost of development. It is unlikely that in-service training costs will be less than this percentage of true recurrent costs.

There is a considerable need of research on the economic impact of training. It is often difficult to either measure immediate, tangible benefits from investments in training or express these benefits in terms of, for example, yield increase. Yet there are strong indications that successful irrigation development and sustained snd appropriate management can only be achieved when adequate training is provided at the various levels. It is therefore essential that methodologies are developed which will determine the impact of training in economic terms and that studies are carried out on well managed irrigation projects, in which training has been built in from the stsrt, to evaluate the impact of the training.

## IV. MANPOWER PLANNING

### IV.1 Introduction

The planning of training programmes should fit within a national policy of human resources development for irrigation management. Establishing this national policy is a necessary and vital step before an effective training programme can be developed. A national policy should be bssed on the identification of problems for which training is needed and the subsequent assessment of manpower needs.

The principles of manpower planning are conceptually straight forward (Figures 1 and 2). In the data scarce situation of sub-Saharan Africa, more complex approaches than the one described are inappropriate.

An analysis of both the present and future **demand** for trained manpower is carried out, together with an evaluation of the existing **supply**. Demand and supply are then reconciled snd a detailed manpower **strategy** produced. The aims of the strategy are to produce sufficient **numbers** of personnel of the appropriate **quality**, operating within the institutional framework necessary for irrigation development to succeed. After **implementation** of the strategy, it is subject to regular **review** and is revised as required.

## DEMAND

### IV.2 Steps Involved

The first stage on the demand side is to derive projections of the future development of irrigation in the country. To allow for educational lead times, these projections need to cover at least the next 10 years and preferably the next 25 to 30 years.

The second stage is to develop manpower models which comprise the organisational structures, job descriptions and staff numbers at each level for the types of irrigation to be developed. The projections for irrigation development are then combined, year by year, with the staffing norms in the manpower model to give annual estimates of the numbers required. Allowances are made for wastage (i.e. leavers) in determining the snnual recruitment demand.

The recruitment demand is then offset by the time required for education (educational lead time) and increased to take account of wastage from education expected annually. The result is the year by year requirement for education places.

Whilst the methodology outlined above appears relatively straightforward, its application in practice is not so simple.

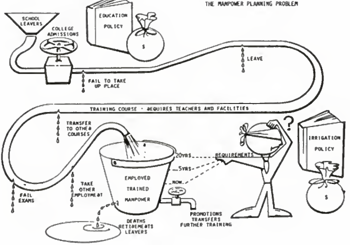
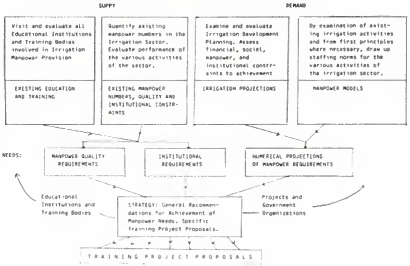



FIGURE 1
THE MANPOWER PLANNING PROBLEM

Figure 2 - Manpower Planning Methodology



### IV.3 Future Rates of Development

The area which can introduce the greatest uncertainty is the estimation of future rates of irrigation development. Planning projections must be realistic, but their absolute accuracy is less important. These projections should always be made in the light of previous growth rates actually achieved, in order to ensure some realism.

A distinction can be made between realistic growth projections and planning targets. If the former are used in manpower planning, the manpower shortfalls may not be completely eliminated. A considerable degree of judgement is needed to identify the most appropriate planning projection.

Projections should cover not only the **rate**, but also the **types** of development. The factors which most influence manpower requirements are the type of schemes (estates, formal smallholder schemes, informal schemes), area to be irrigated, method of water application and cropping system.

### IV.4 Manpower Models

The term "manpower model" is used to describe the management structure of an organisation, the numbers of people and the skills needed to carry out the functions of the organisation. In this context, the manpower models include only the requirements for irrigation manpower (see Section II.3). This assumes that the requirements for other types of manpower are unlikely to be a constraint on the development of irrigation. Where this assumption is not true, the model must be extended to include other manpower requirements.

In establishing manpower models, the organisations which need to be considered are:

- the bodies involved in the planning, design, construction, operation, maintenance and rehabilitation of existing and future irrigation schemes in the public and private sectors;

- research bodies;

- education and training institutions.

Ideally the manpower models used in a particular situation are derived from a full evaluation of irrigation schemes or organisations which:

- are of a similar type (size, crops, objectives, etc.);
- operate within a similar institutional framework (preferably in the same country);
- are generally considered to be successful.

### IV.5 Wastage Rates

The values used for wastage rates should ideally be actual rates over a reasonable period of time (say 5 years). Frequently this is not possible and then estimates must be made. Where institutional aspects such as poor salaries, lack of motivation or very isolated irrigation schemes are causing high wastage rates in the existing irrigation sector, plans for the future may use a lower rate on the assumption that the root causes of the high rates are to be tackled as part of the future strategy. Typical annual wastage rates for agricultural manpower in Africa have been found to be 3-5% (professional level) and 4-6% (technician level).

### IV.6 Existing Manpower Needs

An evaluation of existing irrigation developments and organisations will indicate if there is already understaffing or shortages of particular skills. At the professional level, a shortfall in numbers will often be reflected in the employment of large numbers of expatriate staff. At all levels, a shortfall in either numbers or quality may be reflected in poor performance of the schemes.

**SUPPLY**

The supply side consists of the existing manpower pool (i.e. those in post or available for employment) together with the regular output from educational institutions and training provisions. Quality and institutional issues are particularly important in evaluating these aspects.

**IV.7 Irrigation Sector**

Poor design of irrigation schemes and inefficient management of schemes and organisations are often blamed on insufficient numbers of staff in post. However, it is rare that the most effective use is being made of existing staff.

Present manpower may be inadequately trained, lacking in practical and management skills and lacking confidence. Inefficiencies in the employing organisations - such as inadequate operating budgets and lack of incentives - may also severely constrain staff performance.

Until these apsects of manpower quality and institutional performance are recognised and steps are taken to rectify them, additional manpower will only be a burden on the organisations.

Formalised and initially intensive provision of in-service training (see Section III.2), including management studies, will be essential to tackle these problems. It may be necessary at the same time to reform or reorganise the organisations themselves.

**IV.8 Education and Training**

In evaluating the education and training currently available, it is necessary to examine both institutional education courses and in-service training provisions.

Educational institutions in the Region share many of the difficulties of other public bodies - i.e. limited operating budgets, understaffing, lack of resources and inexperienced staff. These factors contribute to the theoretical and conventional styles of teaching often found. The amount of practical work, design work and field studies is a good measure of the quality of education being provided. Other indicators are unit costs, staff/student ratios, staff qualifications, pass rates, curriculum content and resources.

In-service training is rarely provided on a formal and organised basis. Use of national, regional and international bodies for this should be examined and the effectiveness assessed.

**STRATEGY**

The overall aim of a manpower planning strategy is to ensure that development can proceed free from the constraints imposed by manpower shortfalls.

**IV.9 Future Strategy**

To develop a strategy, the manpower demand is compared with the available supply so as to clearly identify when and why shortfalls in numbers, quality or institutional performance occur.

Specific proposals and recommendations can then be made to reconcile the supply and the demand.

Specific proposals and recommendations need to consider:

- the establishment at existing irrigation schemes of high quality management charged with a training role. This is for students to obtain work experience and for in-service training, especially at middle and professional levels;

- the strengthening of selected educational institutions (and, if necessary, the creation of new ones) through staff development, curriculum improvement, equipment and resources;

- the establishment of Professional and Technical Institutes to oversee and assess post qualification experience leading to professional and technical recognition;

- at vocational level, the setting up or strengthening of a national irrigation skills testing scheme;

- the use in the short term of overseas educational institutions which can offer appropriate long courses and short professional development opportunities;

- training and professional development for training officers employed in government ministries, parastatals and on irrigation schemes.

In practice, arriving at a realistic strategy may require modification of the targetted irrigation growth rates, for example slowing the initial rate of development or phasing in the retraining of employees. Once the implications of proposed growth rates are clear, it becomes possible to set realistic development targets and to plan manageable growth in the education and training sectors, which in turn will lead to a strategy which has a greater chance of success.

### IV.10 Implementation and Review

Successful implementation of the manpower planning strategy requires recognition at a high level that the supply of trained manpower is as important for the development of irrigation as, for example, the engineering, agronomic or marketing aspects.

It also requires recognition that a vital feature of the implementation is to regularly update the information and assumptions underlying the strategy as more information becomes available.

Formulation and implementation of the strategy in the long term will be aided by the creation of an Irrigation Manpower Planning Board at a sufficiently high level to be able to decide policies and priorities.

This Board should contain representatives from the Ministries concerned with agriculture, irrigation and education and also, representatives from areas such as rural development, water supplies, public works, finance and planning.

The Board should be involved in the initial development of the strategy and then be responsible for its subsequent implementation and review on a regular basis (every 2 or 3 years). Revised estimates of rates of irrigation development, changes in priorities, more refined staffing models and changes in institutional education and training can all be taken into account and the strategy revised accordingly. Without this regular revision, the strategy will quickly become outdated and irrelevant.

The Board will need to set up a monitoring system for gathering and processing information about the rates of irrigation development, operation and management of irrigation schemes and the operation and success of education and training.

## V. AN ILLUSTRATIVE EXAMPLE

### V.1 Introduction

The manpower and training implications of particular development rate targets are not immediately obvious.

This example is therefore included to illustrate the effects of a proposed rate of irrigation development on demand for irrigation manpower and training. It is not based on a particular country or development plan, but the various values used are typical of those which occur in sub-Saharan Africa.

For clarity, the example is greatly simplified and concentrates on only the numerical aspects of manpower demand. In reality, complex issues relating to the quality of manpower and the institutional aspects of irrigation and training need also to be considered.

### V.2 Background

The example is based on a country having an existing irrigated area of 50 000 ha and a target development rate of 10 000 ha/year to be reached by 1990.

Development will be concentrated in the formal sector with the establishment of Government assisted smallholder schemes. A "typical" scheme size is 2000 hectares and so 5 such schemes should come into operation each year, once the full growth rate has been achieved. The present growth rate is only 500 ha/year.

The manpower models for (a) planning, design and construction supervision and (b) operation and maintenance are presented as Tables 3 and 4.

Existing manpower in post (Table 5) is adequate in numbers (being mainly employed in operation and maintenance of existing schemes), but there are substantial needs for in-service training. Wastage rates from employment and from education are given in Table 5, as are the number of places available in educational institutions at the present time.

### V.3 Manpower Requirements

Table 6 shows in detail the procedure for calculating the numerical manpower needs. The year-by-year stream of irrigated areas is combined with the manpower models for planning, design and construction, and operation and maintenance, to give numbers required in post annually. Allowances are then made for wastage and educational lead times to arrive at a year-by-year stream of places required in educational institutions. The table only shows professional level manpower needs; the requirements at technician and vocational level are calculated in the same way, and these are shown in Figure 3. Figure 4 shows a breakdown of the vocational level numbers to illustrate the effects of wastage.

### V.4 Implications

The main implications of this numerical analysis are:

- there is an immediate need to increase the number of places in all three levels of institutional education. At the professional level, the effect of educational lead times is most marked (Table 6), showing that the present number of course places was adequate three years ago, but now (1985) is only half of what is required. The effect of educational lead times can be alleviated by delaying or reducing the development targets, accepting a manpower shortfall in the medium term or employing expatriates;

- the requirement for education places increases annually. This is the case even when development is at a constant rate, because of wastage. If new developments were to cease, the requirement would fall to the level required to replace wastage from the existing workforce;

- the wastage rates have a significant effect on the number of course places required. Action to reduce the numbers lost from both education and employment each year can potentially be very beneficial;

- when operation and maintenance of both agricultural and engineering aspects are the responsibility of government employees (rather than farmers), the operation and maintenance staff needs far outweigh the needs for planning, design and construction supervision.

**Table 3 - Manpower Model - Plenning, Design end Conetruction Supervieion**

These professional level staff sre deployed in e plenning and design unit which will be steffad as follows (total numbers in post):

| Yaer: | 1985 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engineers | 2 | 3 | 4 | 5 | 5 | 5 | 5 | ---------------------------> | | | | | | | | |
| Agronomists | 1 | 2 | 2 | 3 | 3 | 3 | 3 | ---------------------------> | | | | | | | | |

Esch angineer will be supportad by 4 tachniciens.
Esch agronomist will be supported by 2 tachniciens.

**Table 4 - Manpower Model - Operation and Maintenance Steff Per 2000 ha Scheme**

Projact Msnager (P)

Assistant Menager (P) (Engineerlng)

Tech. Tech. Tech. Tech.

12 Fiald Assistents (V)

Assistant Msnsger (P) (Agric)

Tech. Tach. Tech. Tach.

12 Field Assistants (V)

Summary for Scheme:

| Level | Totsl Number |
|---|---|
| Professional (P) | 3 |
| Technician (T) | 8 |
| Vocetional (V) | 24 |

**Teble 5 - Existing Manpower Situation**

Irrigation Manpower Employed:

| Level | No. Employed | Annuel Westaga from Employmant |
|---|---|---|
| P | 78 | 5% |
| T | 210 | 6% |
| V | 600 | 8% |

Education Places Aveileble:

| Leval | No. of Places | Annuel Wastage from Education |
|---|---|---|
| P | 10 | 5% |
| T | 25 | 8% |
| V | 50 | 10% |

V.5 **The Real Situation**

The real situation is usually far more complex than that described. Other types and sizes of scheme should ideally be taken into account. Staffing levels may be reduced in time, for instance as farmers become more experienced. A constant high rate of development may not be sustained for many years. And there may be significant existing staff shortfalls to be met in a phased manner over several years.

Despite these reservations, practical manpower planning will make simplifying assumptions such as those included in the example. Modifications will be built in as the plan is revised and regularly updated.

V.6 **Strategy**

The strategy to meet the manpower needs implied in this illustrative example must include:

- short to medium term measures to upgrade existing staff skills through in-service training;
- strengthening of educational institutions in order to ensure the provision of future manpower requirements;
- the establishment of permanent, structured, in-service training to continue the development of all existing and new staff;
- the establishment of the institutional mechanisms necessary to implement and regularly revise the manpower plan.

**VI. CASE STUDIES - NIGERIA, TANZANIA AND ZIMBABWE**

VI.1 **Introduction**

Three case studies are used to point out the variety of irrigation practices, manpower needs and training requirements within the African continent. They have each been the subject of recent irrigation manpower studies at detailed or preliminary levels.

VI.2 **Nigeria**

Nigeria is of interest here not only because of the plans for major expansion in both formal and informal irrigation, but also because a detailed manpower study was undertaken for the irrigation sector in 1982.

Existing and planned irrigation

This manpower study indicates that in the **formal sector** about 30 000 ha were irrigated in 1982, mainly in the north of the country. Development of formal irrigation schemes began in the late 1940s. Approximately 1.4 m ha have been identified with a potential for development, mainly in large or very large schemes under the control of River Basin Development Authorities (RBDAs).

**Informal irrigation** however, covers an estimated 800 000 ha already. Until recently, this activity has not been supported by Government, but now some of the World Bank funded Integrated Agricultural Development Programmes (ADPs) are providing technical and extension support. The potential for this sort of (small scale) irrigation may be as much as 2 m ha.

In the manpower study referred to the following targets were used for planning purposes:

- Formal irrigation: growth from 30 000 ha in 1982 to 1.4 m ha in 2005, consisting of "typical" schemes of 20 000 ha each.
- Informal irrigation: growth from 0.8 m ha in 1982 to 2.0 m ha in 2010.

Table 6 - Manpower Needs and Education place Requirements for Professional Staff to Year 2000

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Irrigated Area (ha) and no. of typical schemes (end of year) | Development Rate (ha/yr) | Professional Staff Required in Post | | | New Posts Required (3) | Wastage from Employ. (4) | Total Recr. Needed (5) | Education Places Required (6) | Year in which Ed. Start (7) |
| Year | | | O & M (1) | Planning, Design & Constr. (2) | Total | | | | | |
| 1984 | 50000 (25) | 500 | 75 | 3 | 78 | | | | | |
| 1985 | 52000 (26) | 2000 | 78 | 3 | 81 | 3 | 4 | 7 | 8 | 1982 |
| 1986 | 56000 (28) | 4000 | 84 | 5 | 89 | 8 | 4 | 12 | 14 | 1983 |
| 1987 | 62000 (31) | 6000 | 93 | 6 | 99 | 10 | 5 | 15 | 17 | 1984 |
| 1988 | 68000 (34) | 6000 | 102 | 8 | 110 | 11 | 6 | 17 | 20 | 1985 |
| 1989 | 76000 (38) | 8000 | 114 | 8 | 122 | 12 | 6 | 18 | 21 | 1986 |
| 1990 | 86000 (43) | 10000 | 129 | 8 | 137 | 15 | 7 | 22 | 26 | 1987 |
| 1991 | 96000 (48) | 10000 | 144 | 8 | 152 | 15 | 8 | 23 | 27 | 1988 |
| 1992 | 106000 (53) | 10000 | 159 | 8 | 167 | 15 | 8 | 23 | 27 | 1989 |
| 1993 | 116000 (58) | 10000 | 174 | 8 | 182 | 15 | 9 | 24 | 28 | 1990 |
| 1994 | 126000 (63) | 10000 | 189 | 8 | 197 | 15 | 10 | 25 | 29 | 1991 |
| 1995 | 136000 (68) | 10000 | 204 | 8 | 212 | 15 | 11 | 26 | 30 | 1992 |
| 1996 | 146000 (73) | 10000 | 219 | 8 | 227 | 15 | 11 | 26 | 30 | 1993 |
| 1997 | 156000 (78) | 10000 | 234 | 8 | 242 | 15 | 12 | 27 | 31 | 1994 |
| 1998 | 166000 (83) | 10000 | 249 | 8 | 257 | 15 | 13 | 28 | 33 | 1995 |
| 1999 | 176000 (88) | 10000 | 264 | 8 | 272 | 15 | 14 | 29 | 34 | 1996 |
| 2000 | 186000 (93) | 10000 | 279 | 8 | 287 | 15 | 14 | 29 | 34 | 1997 |

Notes

(1) From O & M Manpower Model (Table 4) and Col. 2
(2) From Planning, Design & Construction Model (Table 5) and Col. 2
(3) Obtained from year to year differences in Col. 6
(4) Based on percentage rates in Table 5 and Col. 6. Rounded to nearest integer
(5) Sum of Cols. 7 and 8
(6) From Table 5 and calculated as Col. $9/(1-r)^n$ where r = wastage rate (as a fraction) and n = no. of years in education (3 in this case)
(7) Allowing for 3 year lead time, i.e. dates offset by 3 years.

FIG 3 - EDUCATION PLACES REQUIRED AT ALL LEVELS

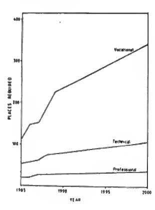



FIG 4 - EDUCATION PLACES REQUIRED AT VOCATIONAL LEVEL

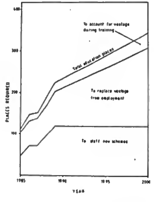
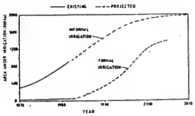


Figura 5 shows these and previous projactions for Nigerian irrigation as well as the actual growth to dste.

FIG5 - EXISTING AND PROJECTED IRRIGATED AREAS IN NIGERIA




## Government policy

Although irrigation has high priority in budgetary terms, government policy has not been explicit on targetted growth rates, nor on the relative importance to be given to the formal and informal sub-sectors.

In most of the formal schemes, smsllholders have been settled (or resettled) on fsmily plots of 0.5-4 ha in size. Initially however, their rolas have baen very restrictad, with project management (O & M) staff taking responsibility for many of the agricultural tasks. Consequently, the numbers of staff required for O & M are very large.

## Manpower needs and training requirements

In line with the country's ambitious development aspirations, the numerical manpower neads ara vary larga. At tha beginning of the 21st century, it ia estimated that over 700 professionals, 2000 tachnicians and nearly 7000 vocational level staff will be requirad in post.

Places in educational institutions will consequently need to treble at profesional level, ba increased by 50% at technician level and increase by a factor of nine at vocational laval.

The quality of existing staff has been observed to be severely constrained by a lack of practical and management training. These aspects could be greatly strengthened in institutional eduation courses.

## VI.3 Tanzania

Tanzania provides an interesting csae study because of its ambitious plans to expand small scale and village irrigation rapidly, following disappointing rasults from formal larga scale smallholdar schemes and parastatal farms.

## Existing and planned irrigation

Estimates for the area under irrigation are givan in Table 7.

Table 7 - Areas under irrigation in Tanzania, 1985

| Category | Area (ha) |
|---|---|
| Traditional small scale and village irrigation schemes | 114 000 |
| Large scale farms (formal irrigation) | 40 000 |

The main emphasis of Government action, through the Irrigation Division of the Ministry of Agriculture, is to promote village irrigation schemes.

A recent study suggests targets of an additional 9000 hectares under full water control (mainly in village schemes) by 1990 and a further 20 to 25 000 hectares by 2000 would be realistic (i.e. a growth rate of 17-1800 ha/year).

A particular problem in forecasting in Tanzania is the extent to which development is dependent on external funding. Projects are put up to a wide range of funding agencies, and the timing and priority of development depends on individual agencies' circumstances rather than a logical ranking and sequencing.

Manpower requirements

Where schemes are small and dispersed, considerably higher staffing levels may be required than for larger schemes. On such small projects however, most of the development inputs could be undertaken by a broadly trained Irrigation/Agricultural Engineer with technician support.

The manpower required for operation and maintenance depends critically on the degree to which control of village irrigation schemes will eventually be handed back to farmers.

Trained staff will also be required in the University and technician level Colleges, research centres, and in the parastatal and private farms.

Using the methodology discussed in Chapters IV and V, the gross minimum training places required have been calculated and are presented in Table 8.

Table 8 - Gross minimum training requirements

| Year of Entry | Training Places Required | |
|---|---|---|
| | Professional Level | Technician Level |
| 1985 | 10 | 45 |
| 1990 | 11 | 40 |
| 2000 | 12 | 50 |

Assumes:

(i) Present shortfall made up over first 5 years intakes
(ii) 5% wastage of staff in post per annum
(iii) 4 year lead time for professional training; 2 years for technician level training
(iv) 10% wastage of training places.

Existing education and training

Most engineering graduates in the irrigation sector have degrees in Civil Engineering. A degree in Agricultural Engineering is now available, but facilities for teaching irrigation are virtually non-existent. A proposal to develop a Soil and Water Engineering option is under consideration.

As an interim measure, students have been sent for civil engineering degrees in India. Postgraduate training is generally undertaken abroad.

At technician level, the major supply of manpower is through the Diploma in Irrigation course at Nyegezi. This is a well developed course with a substantial practical

element and well trained staff. However, the annual intake has recently been reduced from 50 to 25 to match facilities.

There is no organisation specifically running in-service training courses in irrigation.

VI.4 **Zimbabwe**

Because of the differences in the way irrigation has developed in Zimbabwe, there are major differences in the manpower requirements compared to Nigeria and Tanzania.

Most of the 160 000 ha under irrigation is in the large scale private farming sector. Zimbabwe is a net exporter of agricultural produce and has one of the highest irrigated wheat yields per ha in the world. A small but nonetheless important part of the irrigation sector is the small scale irrigation schemes formally run by Government to stimulate development in the poorer rural areas.

The potential for future development is significant. It is provisionally estimated that more than 600 000 ha are potentially irrigable. As most of the current direct river abstraction is accounted for, any major expansion will require the development of major storage works.

Future developments

Although no official projections are available for the future, growth will continue to be in the private sector and an estimated target rate of 6500 ha/year should ensure that development is not constrained by a shortage of trained manpower.

Manpower

Existing and future manpower demands are somewhat different to those of Nigeria and Tanzania. Irrigation is mainly in the private sector and is only one of many skills needed by farmers and field managers and a high level of mechanisation experience is required. Wastage is also much lower because there is very little drift from the small Government sector into the predominant private sector. Because the private sector is successful, there is very little subsequent drift from agriculture into other occupations.

The available staff is mostly young and qualified but rather inexperienced. There is a need to build increased capacity to sustain irrigation and to provide for the future. To meet both private and government manpower needs over the next 10 years, it is estimated that on average 9 professional, 26 technical and 10 vocational training places will be needed each year.

Doc. III-B (2)
(Original in English)

# WOMEN IN IRRIGATED AGRICULTURE IN AFRICA

**SUMMARY**

This paper focuses on the role of women in irrigated agriculture. It does not aim to separate women from their families and promote individualism. Rather the paper argues that, in order to promote the development and welfare of rural families, understanding of the complementary contributions of men and women is essential. The paper further stresses the need to build on traditions and minimize disruptions, utilizing both women and men's potentials.

So far more attention has been given to men's work and contribution to family welfare. The balance needs to be rectified and more attention given to women's needs, problems and potentials, which for cultural, social, religious and economic reasons may be different from men's and less visible.

Chapter I highlights the important role African women traditionally play in agriculture. Women contribute as much as two-thirds of all hours spent in African agriculture.

Chapter II indicates the changes in women's roles due to the introduction of irrigation. Not only does irrigation change women's roles in food and cash crop production, it may also have implications for animal production and household tasks.

With respect to food and cash crop production, irrigation schemes invariably add to the labour required of women when they involve crops for which women have responsibility. A distinction has been made between women as plot users/owners, as family labourers and as wage labourers.

Women's tasks related to animal production may change with changes in availability of water and fodder for the animals. Women's domestic tasks may be affected by the introduction of irrigation, in particular those tasks relating to domestic water, maintaining family health and firewood collection.

Chapter III discusses the need to ensure women's access to production resources and support services. As food and cash crop producers, women and men alike need access to land and water, to equipment and production inputs, to credit and marketing facilities, to water user organizations, and to training, extension and research.

Chapter IV discusses strategies for involving women in irrigated agriculture. Such strategies are based on identification of the target groups, collection of data on the socio-economic organization of farming, assessment of the impact of irrigation development, identification of constraints and potentials, and design and implementation of measures to overcome these constraints and utilize the potentials.

* * * * * * * * *

## I. WOMEN AND AFRICAN AGRICULTURE

African rural women grow, process, market, store and prepare food. They earn income in the agricultural sector through the sale of products and through wage labour. National statistics, derived from agricultural censuses, show that women constitute 46 percent of the agricultural labour force in sub-Saharan Africa. This estimate, however, is conservative inter alia because much of women's work is outside the cash economy, is home based and seasonal in nature. More detailed studies show that women contribute as much as two-thirds of all hours spent in African agriculture (Ref. 1).

The sexual division of labour, although varying from country to country and even within countries, is based on tasks whereby women provide most of the labour required for weeding, harvesting, transporting, storing, processing and marketing of crops in addition to carrying water and fuel, preparing food and taking care of the family. Men provide most of the labour for land clearing and preparation, and hunting. Other tasks are shared equally, as can be seen from Table 1 (Ref. 2, adapted).

Table 1 - Division of rural labour by task, by sex: All Africa

| | Percentage of total labour in hours | |
|---|---|---|
| | Men | Women |
| Land clearing | 95 | 5 |
| Land preparing | 70 | 30 |
| Sowing and transplanting | 50 | 50 |
| Weeding | 30 | 70 |
| Harvesting | 40 | 60 |
| Transporting | 20 | 80 |
| Storing | 20 | 80 |
| Processing | 10 | 90 |
| Marketing | 40 | 60 |
| Carrying water and fuel | 10 | 90 |
| Caring for domestic animals | 50 | 50 |
| Hunting | 90 | 10 |
| Feeding and caring for the family | 5 | 95 |

Source: UN Handbook on Women in Africa, 1975 (adapted)

Not only are women the principal producers in the subsistence agricultural sector, especially in food production, they, in addition, contribute substantially to cash crop production in many African countries. In Rwanda, for example, women contribute about 70 percent of the labour for coffee; in Iringa, Tanzania, women invariably outnumber men in cooperative groups growing tobacco (Ref. 3).

The agricultural sector is the major employer for African women, as shown for example by the 1978 Tanzania census: 98 percent of the economically active women are engaged in agriculture, compared with 79 percent of the economically active men (Ref. 3).

## II. CHANGES IN WOMEN'S ROLES DUE TO THE INTRODUCTION OF IRRIGATION

Introduction of irrigation is bound to have a profound effect on the lives of women. Not only will it affect their agricultural activities, both in food and cash crop production, but it may also affect women's water related traditional activities in and around the homestead (Ref. 4). In this context it is important to note that more than 9 out of 10 irrigation systems are also used for non-cropping purposes; canals are being used for bathing, fetching drinking water, washing clothes, watering cattle, etc. (Ref. 5). The importance of irrigation systems is thus potentially more far reaching for women than for men.

The development of irrigation will not only have a differential impact on women and men, it may also have a differential impact on the various categories of women within a community, depending on the traditional socio-economic status of their families. For example, landless women may benefit from an irrigation development scheme if it creates extra opportunities for wage labour, while simultaneously women from families with a landholding within the scheme may lose out when land title and other benefits are granted to their husbands only.

In addition, irrigation development may have a differential impact on the various groups of women within one family; e.g. in families where the older women mainly work on the land and their daughters or daughters-in-law mainly take care of the household activities, or vice versa, the impact of irrigation development will be different for both groups.

The following paragraphs indicate the changes in women's roles and their impact on labour and income that may occur due to the introduction of irrigation with respect to food and cash crop production, animal production and household tasks.

### II.1 Changes in Food and Cash Crop Production

Irrigation schemes invariably add to the labour required of women when they involve crops for which women have responsibilities. Irrigation means an increased agricultural

yield, often double cropping, combined with the introduction of high yielding varieties and new crops, and more time is required to transplant, weed and harvest the produce, all tasks for which African women have traditionally a major responsibility. Men's labour, of course, will also increase with the introduction of irrigation, but their traditional tasks concentrate in those areas where mechanization has often made the work easier: land clearing and land preparation.

Irrigation is likely to have an impact - positive or negative - on the nutritional status of the family. While in some cases irrigation may lead to increased and more reliable food production it may in other cases lead to elimination of traditional foodcrops and, in particular, in the case of monoculture, to a less diversified family diet.

In many sub-Saharan countries women and men have separate but complementary roles and responsibilities, with respect to agricultural production and household obligations (see box). Women may have complementary roles for the same crop as men or men and women may grow separate crops on separate fields. In Tanzania, for instance, millet is considered to be a women's crop, and apart from the initial preparation of the land, all other activities, from planting to storing, are done by women (Ref. 3).

Women's and Men's separate roles and responsibilities

AN EXAMPLE - THE GAMBIA

Among the Mandinka, there has traditionally been a marked sexual division of labour between crops. Women not only cultivate the swamp rice but they are also responsible for organizing production, pay for most of the inputs themselves and control the crop. While some rice plots (called maruos) are used exclusively for household food production, women often have other fields (kamanyangos) where they cultivate a rice crop for their personal use. Some of this rice may be used for ceremonial gifts but most of it is sold to provide a small private income which the women generally spend on condiments and other cooking ingredients, clothes for themselves and their children, small livestock, medicines, travel to visit relatives, jewellery and personal needs.

Men, on the other hand, are responsible for producing the dryland food crops of millet, sorghum and maize as well as the groundnut cash crop. Wives have no rights over this groundnut income and once the men have fulfilled their obligations to ensure that the household members have food, shelter and clothing, to meet the marriage payments of dependent men and to pay for the following season's agricultural production inputs, they can and do dispose of any surplus income as they wish.

Source: Jennie Dey
Women in Rice Farming Systems
FAO, 1984 (Ref. 6)

On a majority of irrigation schemes in Africa either rice (for food and/or cash) or cash crops (sugarcane, cotton, etc.) are grown. Only seldom do irrigation schemes respond to the needs of women and allow for the cultivation of a variety of crops to feed the family. In order not to rely on the output of the irrigation scheme alone and to secure

the provision of additional foodcrops for the family (sorghum, millet, roots and tubers, vegetables, fruits, spices, etc.) uplands and other lands outside the irrigation scheme are cultivated, under rainfed conditions, often by women, which may cause labour bottlenecks. In northern Cameroon, for example, women experienced severe time constraints during those periods when the demand of subsistence farming in sorghum coincided with the peak periods of rice transplantation (Ref. 7).

Women can only respond in two ways to the time constraints imposed on their daily schedule by the irrigation schemes. Either they neglect their responsibility to provide food for the family or, in the absence of adequate incentives, they ignore the work within the irrigation scheme. The former has a detrimental effect on the nutritional status of the family and the latter on the output of the irrigation project.

With respect to women's agricultural labour, a distinction can be made between three main categories:

a. women as plot users/owners
b. women as family labourers
c. women as wage labourers

The categories are not mutually exclusive: a woman may belong to more than one category. She may e.g. own a small plot, but also work as a family labourer. She may be from a family with little land and in addition work as a (casual) wage labourer.

Women as plot users/owners

These women are either female heads of household or women, within male headed households, who actually own or have use rights to land. The women have a large degree of control over their crops and the returns. When their ownership or use rights are maintained with the introduction of irrigation, the women are likely to allocate their labour to the irrigated plots, if the expected return to their labour is favourable. If the use rights, however, are not secure, they may be reluctant to invest their time or other resources in the irrigation development works.

Women as family labourers

These women, as well as other family members, work on the family land, whereby there is usually a division of labour by operation and sex. The degree of control by the individual family members, over their crops and the returns, varies and may be vested in either the husband, the wife or both.

The assumption that the farming family is a homogeneous unit, with one purse, freely interchangeable or free family labour is incorrect and may have severe implications for the results of irrigation projects. With respect to women's willingness to provide labour to family plots several options exist, usually developing from or adapting traditions.

The newly introduced irrigated crops may be considered household crops in which case the women may work on them without remuneration. But, especially in case of irrigated cash crops, the women may only be prepared to work on them after they have fullfilled their obligations to provide family food and if they are assured of a fair remuneration. The latter is confirmed inter alia by a study carried out in Northern Cameroon which shows that the extent to which husbands can mobilize their wives' labour, in this case for rice cultivation, depends on the rate of compensation the husbands offer (Ref. 7).

Women as wage labourers

These women are either from landless families or from families who own little land. This category includes the female labourers on irrigated estates (permanent and casual workers), women who work on neighbouring farms and women who work as wage labourers for their own husbands. It also includes women from families who do not have irrigated land and who perform wage labour on the irrigated lands in the dry season.

If the irrigation water is not considered safe for drinking, shallow wells could be installed, close to the irrigation canals, allowing for filtration and purification of the irrigation water. These wells should be installed, if the conditions permit it, at the head end of the scheme, thus reducing the possibilities of contamination of the water with residues of fertilizers, pesticides and herbicides. Similarly, facilities for washing of clothes, bathing and sanitation should be provided in such a way as to avoid contamination of water used for drinking.

Not only can irrigation systems, when properly designed, contribute to improvements in health, but they can also assist in saving women's time and energy by providing water closer to the homes. This energy and time could then be used for alternate, productive or home-caring activities. In Tanzania, for example, it was found that by halving the time spent on fetching water, the labour released could increase the cropping area by 20 percent (Ref. 3). Since women's already large contribution to agricultural labour tends to increase when irrigation is introduced, irrigation projects must consider ways to lessen women's non-agricultural tasks such as fetching water (Ref. 8).

Another important task usually performed by women, which may be affected by the introduction of irrigation, is the collection of firewood. By clearing land, traditionally used for firewood collection, women may be forced to go further to collect the wood, thus losing costly time. Time could be saved by introducing simple ox-drawn carts to facilitate the transport of wood. Women may, however, have to use upland areas which subsequently could become more vulnerable to erosion. Alternatively women may have to start buying firewood, but it should be kept in mind that the shortage of firewood would not only affect women involved in the irrigation scheme, but also other village women who are not in a position to gain any benefits from such a scheme.

## III. WOMEN'S ACCESS TO PRODUCTION RESOURCES AND SUPPORT SERVICES

Women, as food and cash crop producers, need, like men, access to production resources and support services. The assumption that resources and services will be fairly redistributed within the family, after having been provided to the male head of household, is not valid. It is, for example, obviously inefficient to train men in tasks usually performed by women. Yet, such examples are by no means isolated events; they happen all too frequently, be it usually unintended.

Female-headed households need special attention with respect to access to resources and services. Some 22 percent of the households in sub-Saharan Africa are **de jure** headed by women. In areas of high male migration, the percentage of households **de facto** headed by women is much higher, reaching 63 percent in one southern African country (Ref. 1).

The following paragraphs draw attention to the need to provide women with access to land and water, to equipment and production inputs, to credit and marketing facilities, to water user organizations, to training, extension and research.

### III.1 Access to Land and Water

In particular in those areas where women and men grow separate crops on separate fields and women traditionally have use rights to their fields or are the land owners, irrigation development programmes should ensure that women will have similar rights to the improved fields. In Senegal, neglect of women's land use rights would have resulted in failure of an irrigation scheme, had the male heads of households/compounds not modified the allocation of the land to satisfy women's use rights and thus ensure that the women remained on the scheme (Ref. 3).

Irrigation schemes, by granting formal land title to the male heads of household, eliminate women's land use rights and deprive women of the opportunity to fulfil their responsibilities towards their families (see box).

The introduction of centrally managed irrigation schemes (estates), using wage labourers only, could create employment opportunities for women, both as seasonal and permanent labourers, thus enabling them to provide or supplement the family income. There is evidence, however, that women labourers frequently get paid less than men, while doing similar jobs and women are more often paid in kind. In addition women usually make up a relatively large percentage of the seasonal labour force and a smaller percentage of the permanent labour force.

Care should be taken with the centrally managed schemes that mechanization of on-farm and post-harvest activities does not deprive especially landless women of the often only opportunity to do wage labour. While mechanization may assist women from farming families to lighten their tasks, it may also cause loss of employment possibilities for another category of women: the landless labourers. If mechanization is essential to increase farm production and productivity and it results in a destruction of employment opportunities for landless female labourers, efforts must be made simultaneously to create additional employment in the farm or non-farm sector.

### III.2 Changes in Animal Production and Household Tasks

Animal production

Numerous studies show that African women traditionally have an important role in taking care of livestock, including cows, sheep, goats, pigs and poultry. Women participate in or are responsible for a wide variety of tasks such as feeding the animals, cleaning the stables, collecting manure for fertilizer or fuel, watering the animals, milking, making butter and cheese, marketing of dairy products, etc.

Irrigation schemes may facilitate animal husbandry, by improving the availability of drinking water and fodder crops for the animals.

Women traditionally may have to go far to fetch water for the animals or alternatively bring their animals to the water. In some cases irrigation projects have provided separate reservoirs for watering the animals, lest they destroy the irrigation canals.

Irrigation development may allow for the production of fodder. When fodder crops are grown, women can cut daily the amount of fodder required or sell gradually small quantities and thus obtain a regular supplemental income. In addition the animals may be allowed, sometimes against payment, to graze the stubble or eat the crop residues after the harvest.

Care should be taken, however, that irrigation systems do not unduly destroy traditional off-season grazing areas or access to traditional water points.

Household tasks

Women traditionally perform many household tasks, of which several are water-related, including fetching drinking water, washing clothes, bathing, etc.

In large irrigation schemes, the supplies of irrigation water for the crops ensure that the much smaller human needs are satisfied without much difficulty, almost as a by-product. In such schemes, the problem is not the water quantity but the water quality. Unpolluted water for human consumption is rarely obtainable from canals or ditches. When people in some 95 percent of the irrigation systems are using untreated water, not meant for human consumption, they are exposed to a variety of illnesses (Ref. 8). It is, however, often suggested that an increased quantity of water is more significant for improving health than is improved quality of water. Thus, dual purpose systems, for irrigation water and drinking water, could substantially improve health.

A key question is: how can irrigation projects, when initially planned, be designed in such a way that they provide safe water for domestic needs? Can the designs be made in such a way that the exposure to illnesses is at least minimized?

### III.3 Access to Credit and Marketing Facilities

Credit facilities, for the purchase of inputs such as seeds, fertilizers, pesticides, herbicides, tools, etc., are obviously vital for both male and female agricultural producers.

With regard to credit, the three most common forms of collateral required for agricultural loans - land title, cattle, or cooperative membership - are rarely available to women farmers (Ref. 1).

Alternative types of collateral for loans need be and are being identified; these include the establishment of funds to guarantee bank loans for women's groups and the establishment of revolving funds for women's groups (Ref. 1).

In most African countries women predominate in rural markets - both as buyers and sellers of food and other goods. The lack of adequate marketing facilities and unstable or poor prices can be a disincentive for women producers; they must be assured of outlets if they are to strive for a production surplus. Participants in a seminar for women traders in Ghana in 1977 asked for improved facilities in the local market places, including better sanitation, more effective shelter against the sun and rain, more space, and day-care facilities. This kind of upgrading of facilities could encourage more buyers and sellers and attract young mothers with children (Ref. 1).

### III.4 Access to Water User Organizations

Water user organizations can be an important mechanism to enhance women's participation and facilitate women's active involvement in decision making with respect to all phases of irrigation planning, development and management.

Water user organizations may take different forms in each country, but their major functions generally include:

- distribution of water between users
- maintenance of the canal system and related structures
- fee and fine collection
- resolving water disputes among farmers
- taking loans for construction or improvement purposes
- involving farmers in the decision making process
- presentation of the farmers' views to government agencies and water authorities
- provision of an organized means for extension and farmer training
- mobilization of local resources (cash or kind) to construct, improve or maintain facilities.

From the above, it is obvious that if women are excluded from active participation in these organizations, e.g. by granting membership to the head of household or to the landowner rather than the cultivator, the organizations will lose the benefit of women's experience and women will be deprived of the benefits and services provided by the organization. The water user associations should ensure that all cultivators contribute fully to the running of the organizations and also benefit from their services.

In this respect it is also important that women are, as appropriate, represented in the Board of Directors, the Management office, Executing Units, Judicial Sections, etc.

### III.5 Access to Training, Extension and Research

Especially with the introduction of irrigation, combined with the introduction of new crop varieties and improved agricultural practices (pesticides, fertilizers, herbicides, etc.), adequate training and extension services are required, for women and men alike.

Women's Access to Land

SOME EXAMPLES

"There is evidence that when land is improved for partial or complete water control, women tend to lose traditional use rights to land unless special provisions are introduced to protect their access to the improved land. For example, in the Banfora region of Burkina Faso women grow swamp rice as a personal crop. They have direct access to this land through the traditional "Lord of the Land" who generally confirms the transfer of rights from mother to daughter. After improved water control and drainage systems were developed in these rice swamps, the land was reallocated by the project to male household heads .....

"In The Gambia only men were invited to take part in the development of small-scale rice irrigation schemes. Since ownership rights are established by the act of clearing and bringing land under cultivation, women have been effectively excluded from ownership of these plots despite the fact that traditionally they were almost exclusively responsible for rice cultivation.

"A positive example is provided by a project developing rainfed and irrigated rice land in Zanzibar. Based on a recognition of women's almost exclusive responsibility for subsistence food-crop production and their limited decision-making power within the household, both men and women are able to register individually as tenants. Women at present account for more than half the tenants. The scheme is popular among the women since they have direct access also to the improved inputs and credit."

Source: Jennie Dey
Women in Food Production and Food Security in Africa
FAO, 1984 (Ref. 9)

As indicated in the previous chapters, women' water-related tasks are numerous. Irrigation development projects and programmes can substantially improve the well-being of women and men, but should, to the extent feasible, ensure that women have access to water, not only for their major crops (rice and/or cash crops) but also for example for vegetable gardens, either near the homestead or within the main scheme. In addition, provisions may be required to facilitate the collection of safe drinking water, bathing, the washing of clothes, and watering of animals.

### III.6 Access to Equipment and Production Inputs

Access to land and water is not enough to ensure adequate household food production. In addition production inputs - such as seeds, fertilizers and pesticides - and agricultural equipment may be required, to maximize yield and overcome labour shortages.

Women often do not have access to capital equipment, such as tractors, ploughs, threshers, etc. If the equipment is household or male owned, women may only be able to use them after the men have finished - often too late in the season to be really effective.

Capital equipment is usually purchased by men who have larger cash crop and non-farm incomes and is usually inherited by men. Specific measures may be required to ensure women have access to equipment and production inputs.

In addition to the more general constraints to adequate training and extension services, such as insufficiently trained and supported extension workers, women producers encounter additional problems. For example, public discussion meetings are often held at times convenient to men but when women are unable to attend; information is released through channels such as pamphlets, radios, or posters, which are less accessible to women; farmer training is held at centres which provide no separate facilities for women and which do not cater for small infants; courses are often too long for women to leave their families. Demonstrations are given to men as heads of farming families, even if the activities shown are in fact carried out by women. Furthermore, women's full participation may also be hindered by cultural and social norms which prevent male extension agents from working with women on an individual basis (Ref. 10).

Since relatively few women are being trained as agriculturalists, there are substantially more male than female extension workers which accentuates women's differential access to extension services. The answer to the problem will not necessarily come through the establishment of a separate unit of female agricultural agents who work only with women farmers, except in specific cases where cultural practices and religious customs make it difficult or impossible for male agricultural agents to work with female farmers. Where possible, extension workers should not only use male farmer leaders but also women farmers as contact or demonstration farmers. Also, women farmers should be encouraged to seek out the help of extension workers instead of waiting for their visit. In general, the answer lies in the development of new strategies in extension programming which are sensitive to the needs of women farmers and are responsible to them (Ref. 10).

Most of the current agricultural research is not adequately geared towards meeting the farmer's needs and even less towards the needs of the female farmers. The latter, because there is still a basic misunderstanding of the farm household structure; most research does not take into account the complexity of the farm women's roles within the household (Ref. 10). An alternative strategy: the farming system research (FSR) approach may improve this situation. The FSR approach aims to look at the totality of the farm, in its socio-economic context and includes livestock production, off-farm employment and post harvest processing. FSR would thus provide the linkage between the technical/research component and the farmers, with the farm household participating actively in the development of strategies for rural improvement (Ref. 10).

## IV. STRATEGIES FOR INVOLVING WOMEN IN IRRIGATED AGRICULTURE

Unfortunately, no simple, universally applicable strategy can be provided for involving women in irrigated agriculture. The strategies will vary from country to country, since they will need to take account of the specific traditional relationships between women and men, the socio-economic status of the families involved, and the changes occurring in these.

Each strategy, however, should include the following components:

- identification of the target groups
- collection of data on the socio-economic organization of farming
- assessment of the impact of irrigation development on men and women, inside and outside the irrigation schemes
- identification of constraints and potentials in existing and new schemes
- design and implementation of measures to overcome the constraints and utilize the potentials.

Data collection is best done in a quick and cost-effective manner, using the Rapid Rural Appraisal method. Firstly, general data needs to be collected on the socio-economic organization of farming in the area. Secondly, based on the global picture thus obtained, specific questions can be formulated which enable the assessment of the impact of irrigation development.

In the following paragraphs the five major components of a strategy to involve women in irrigated agriculture have been further elaborated.

## IV.1 Identification of the Target Groups

The different target groups or intended beneficiaries must be clearly identified - unless this is done during project design, there is little chance that the desired target group will benefit (Ref. 11).

The target groups need to be identified by socio-economic status and sex as this is critical for determining the type of technology and delivery system to be used.

In addition, it may be necessary to identify the poor and disadvantaged within the area selected for project implementation. In some areas, people share the same standard of living. More commonly, however, significant disparities exist in access to resources, supplies and services. Although an irrigation project may be established in an area in which land appears to be equitably distributed there are usually farmers who have the best irrigated land and control over the water supply. Similar situations occur with respect to the benefits of new technology packages, extension and supply services etc. Without clear specification of the target groups and compensation for inequities in project design, these tendencies will worsen. For example, inequities may be worsened within the household if women's labour is required for project activities, but the benefits accrue to the male head of households (Ref. 11).

A field investigation, as described in the following paragraphs is a useful means to identify the disadvantaged groups and enables identification of the envisaged project beneficiaries.

## IV.2 Collection of Data on Socio-economic Organization of Farming

There is a need to collect general information on women's and men's roles and responsibilities within the various target groups: on-farm, off-farm and in the homestead. Both women and men need to be consulted on their respective water related tasks. Key questions include:

- do women and men grow separate crops on separate fields (simultaneously or in rotation) or do they have complementary roles for the same crops?
- who traditionally owns or has use rights of the land? What are the inheritance laws and customs with respect to land ownership and use right?
- who is responsible for the provision of the production inputs (seeds, fertilizers, etc.) and who has control over the income obtained from the various crops? What are the norms and practices in establishing priorities for expenditure? How are the decisions made about expenditure and/or savings?
- who has major responsibility for the following tasks per crop: land clearing, land preparation, choice of seeds, sowing and transplanting, choice of fertilizers and their application, weeding, choice of herbicides and their application, harvesting, threshing, transporting, storing, processing and marketing?
- who is responsible for the various tasks in and around the homestead, such as carrying water and fuel wood, caring for domestic animals, feeding and caring for the family, house construction and maintenance, construction of latrines etc.?
- who is responsible for the provision of basic household requirements: food, clothes, housing, school expenses, medical expenses, ceremonial expenses (marriage, funerals, etc.)?
- who contributes to the family income, including off-farm employment, family farm labour, agricultural wage labour?
- what percentage of households are de jure and de facto headed by women?

### IV.3 Assessment of the Impact of Irrigation Development

As the introduction of irrigation in itself already has an immense impact on the lives of the farming families, care should be taken to build on traditional customs, activities and responsibilities as much as possible and to minimize disruption. Moreover, the envisaged changes should be acceptable to all involved. For example, providing irrigation facilities only for "men's cash crops" has a differential impact on the socio-economic status of women and men within the family, relatively lowering the status of women. This situation could and should be avoided.

Based on the analysis of the data on the socio-economic organization of farming in the area, specific questions need to be formulated to assess the impact of the envisaged irrigation development on women and men, in particular with respect to labour and income. The various target groups, including farm families and agricultural labour families need to be taken into account and both women and men should be consulted on their expectations of the irrigation project. As the questions depend on the local circumstances, only some examples can be provided; these include:

- who has traditional ownership or use rights over the fields to be irrigated?

- which crops will be irrigated? Are these traditionally women's or men's crops? If new crops are introduced, who is likely to assume major labour and decision making roles, including control of the crops?

- will individual families need to grow additional (food) crops outside the scheme? If so, who will be mainly responsible?

- which specific tasks will be more energy and time consuming and who traditionally performs them? If irrigation increases demand for labour, is extra (family or wage) labour available and at what cost? Are new labour bottlenecks likely to be created? Does family labour have to be renumerated or reciprocated?

- who will benefit from the additional income and in what way?

### IV.4 Identification of Constraints and Potentials

The impact assessment will reveal the major constraints and potentials, in particular those related to women's and men's labour and income.

Additional constraints may be encountered with respect to women's lack of access to production resources and support services. These constraints could relate to:

- land: loss of women's use rights or ownership due to irrigation development by granting land use rights or ownership to male settlers;

- water: limited or no facilities to irrigate vegetable gardens and other foodcrops, or to provide water for household and livestock needs;

- training and extension: few facilities for female trainees; inconvenient timing and duration of courses and demonstrations; male extension workers not trained to work with women; lack of female extension workers;

- research: little recognition of and inadequate programmes to solve specific problems of female farmers;

- credit: lack of imagination in developing means of ensuring credit reliability and regular repayments by women farmers who have no access to traditional forms of collateral, such as land;

- marketing: facilities insufficient for women with children;

- water user organizations: membership is usually limited to heads of households; women are rarely represented in decision making bodies.

## IV.5 Design and Implementation of Measures to Overcome the Constraints and Utilize the Potentials

Once the constraints and potentials have been identified properly, the measures required to overcome the constraints and to build on the potentials, can be more easily devised. Such measures however, are not necessarily easy to implement. While it may be relatively easy to design an irrigation system such as to allow for a variety of crops, it will be a more long term effort to create a cadre of female extension workers.

Measures to utilize the potentials of and to overcome constraints to women's full and active participation in irrigation development and management, are site specific and will thus need to be identified locally and implemented according to priority. In any case, knowledge of women's and men's roles and responsibilities, and the understanding of their significance, will assist governments and others involved in irrigation planning, design, implementation and management to respond better to the needs and wishes of rural men and women.

REFERENCES

1. Women in Agriculture 1: Women in Agricultural Production, FAO, 1984.

2. UN Handbook on Women in Africa. Economic Commission on Africa (ECA), 1975.

3. FAO/Ceres No. 105 (Vol. 18, No. 3) pages 28-32, Confronting the male bias in research priorities, Mascarenhas, Ophelia, 1985.

4. Draft paper: Women in Irrigated Agriculture. Gökgür, Nilgun et al., FAO, 1985. (In preparation).

5. Non-agricultural uses of irrigation systems: Past experience and implications for planning and design. Yoder, Robert. Agricultural Development Council (ADC), 1981.

6. Women in Agriculture 2: Women in Rice Farming Systems. Dey, Jennie, FAO, 1984.

7. Women's labor allocation and irrigated rice production in Northern Cameroon. Jones, Christine, 1982.

8. Preliminary draft: Women/irrigation/drinking water /sanitation in their inter-relationships. Elmendorf, Mary. FAO, 1985. (In preparation).

9. Women in Agriculture 3: Women in Food Production and Food Security in Africa. Dey, Jennie, FAO, 1984.

10. Women in Food Production. Report of the Expert Consultation held in Rome, 7-14 December 1983. FAO, 1984. In particular: Appendixes 10 and 11.

11. Guidelines for Designing Development Projects to Benefit the Rural Poor, FAO, ESH, 1984.

**Doc. III-B (3)**
(Original in French)

**THE ROLE OF NON-GOVERNMENTAL ORGANIZATIONS IN SMALL-SCALE IRRIGATION IN AFRICA**

SUMMARY

**SUMMARY**

In this paper, the term non-governmental organization (NGO) refers exclusively to non-governmental institutions from outside the villages, i.e. support organizations whose status is officially recognized and who promote small-scale irrigation projects in the villages. A distinction is made between foreign and national NGOs.

Chapter 2 provides, based on various contribution papers, a brief overview of NGO experiences in small-scale irrigation projects in Africa.

Chapter 3 highlights NGOs' assets in small-scale irrigation development and management and, in particular, their ability to i) mobilize resources complementary to those of the government, ii) integrate a project in the peasant milieu and iii) evaluate a multiplication of small-scale irrigation projects. NGOs relate to village associations and aim to promote their self-reliance. NGO projects build on what is already done locally and avoid radical interventions. In addition, these projects are formulated with the direct participation of the beneficiaries, they use simple water control techniques and base project management on the existing organizational capacity of the local communities.

Chapter 4 provides a brief overview of the problems encountered by NGOs. They relate to excessive interference by official structures, lack of technical expertise, problems related to land tenure, marketing and pricing policies, and coordination among NGOs and between NGOs and government services.

Chapter 5 provides some suggestions for national NGOs, foreign NGOs, governments and multilateral organizations to promote NGO small-scale irrigation projects.

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## I. INTRODUCTION

The role of non-governmental organizations (NGOs) in development efforts in Africa is increasingly recognized by governments and intergovernmental agencies. By working with the local populations at the village level, NGOs contribute to the promotion of self-reliance of local producers, a policy which is increasingly adopted by African governments. In addition NGOs are able to mobilize funds which complement the often overstretched resources of governments.

It is important to clarify what is meant in this paper by "NGOs". The negative definition of the term "non-governmental organization" runs the risk of creating some confusion. In principle, it should encompass, in addition to national and international private agencies, all village associations and peasant organizations outside the official apparatus set up by governments. It is evident that the rural population and its organizations, whether official or informal, are the basis for all development programmes in the villages, governmental as well as non-governmental. Therefore, this paper will use the term NGO to refer exclusively to non-governmental institutions from outside the villages, i.e. support organizations whose status is officially recognized and which promote small-scale irrigation projects in the villages. By so doing, they relate to existing village associations or encourage their formation wherever they do not yet exist. For many NGOs the stated purpose of their activities is to promote the self-reliance of these local associations in initiating and pursuing their own development.

There is a whole range of NGOs of this kind in Africa. From the point of view of their membership, one may distinguish between, on the one hand, the foreign institutions which have a representative office and sponsor development projects in the country (church organizations, or local branches of Northern-based development aid agencies), and, on the other hand, national support organizations which are local creations. Some of the latter are government-inspired, inasmuch as they are founded and managed by government officials

(as is often the case with the cooperative movement), while others enjoy a certain autonomy vis-a-vis government structures. In the case of Northern NGOs present in Africa, some prefer to work through the local and national NGOs whom they support, while others operate in direct contact with village associations.

In some cases, the NGOs are grouped together in a network in order to coordinate better their activities, to facilitate the training of their staff, to exchange and evaluate their experiences and to provide a valid interlocutor to governments and foreign aid agencies.

## II. OVERVIEW OF NGO EXPERIENCES IN SMALL-SCALE IRRIGATION PROJECTS IN AFRICA

This paper summarizes the findings of several reports* on NGO experiences in the field of small-scale irrigation. It attempts to draw from these reports what is specific to NGOs and does not dwell on aspects which may be common to all small-scale irrigation - governmental and NGO - schemes. The reports present a great variety of experiences and examine small-scale irrigation problems from different and complementary angles.

There are few comprehensive statistics on the significance of non-governmental initiatives in this field. The Burkina Faso paper shows that out of a total of 3 987 projects listed by the NGO Permanent Secretariate (SPONG) between 1975 and 1982, 1 353 had an irrigation component. Irrigation is the most favoured sector, followed by projects related to education and the creation of rural institutions (1 143), projects in the health/social services sector (865) and agriculture/livestock/reforestation projects (551). NGO funds used in the irrigation sector represent more than half of the total investments. As the major part of NGO projects in Burkina Faso relate to water development, it is not surprising that the government recently appealed to them for the construction of more than 250 small dams within the framework of the Government's national davalopment programme. The NGOs in Burkina Faso use an integrated approach to the water problem, not limiting themselves to building irrigation works but encompassing in their action other aspects of village development, as appropriate.

The report from **Senegal** shows how, since 1970, due to diminishing floods, numerous village groups, which had so far practised only rainfed agriculture, were stimulated to develop small irrigated areas using pumps and wells which had previously been used exclusively for household water needs and animals. In some cases there is, in addition to the mobilization of local manpower, a system of voluntary contributions in order to pay for inputs (fuel and oil) and for maintenance. Profits are equitably distributed according to the labour each person has contributed. Some of these local initiatives were later put under the control of state-owned or partly state-owned development institutions. In other cases, irrigation development started with the assistance of national or foreign NGOs. The latter would enter into a contract with the local population or facilitate the creation of cooperatives in the villages, and provide the necessary guidance until they have reached self-reliance and have taken over full responsibility for the project.

In their report, the European NGOs mention a similar situation in **Mali** where the Regional Union of Cooperatives strives to support the peasants to continue the irrigation projects already undertaken. Essential for this purpose is the maintenance of frequent contacts between Union leaders and the persons in charge of irrigated areas in the villages.

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Two country reports, one referring to village associations in **Senegal** and their relations with support organizations from outside the village, and one describing NGO small-scale irrigation projects in **Burkina Faso** in the context of the government's efforts to promote water resource development in this country; two reports on specific irrigation problems, such as water control techniques for swamp rice production in **Sierra Leone** and the impact on small farmers of pump irrigation projects in **Kenya**; and a summary report on projects promoted by **European NGOs** (particularly from France and Britain) in various African countries - Mali, Tanzania, Niger and Chad.

The report from **Sierra Leone**, while emphasizing the significance of water management for swamp rice production, also underlines the village associations' need for support, in terms of provision of tools, credit, etc. In addition, attention is required to solve the health problems related to swamp rice development.

The report from **Kenya** evaluates the impact of small-scale pump irrigation schemes. It notes that rainfed subsistence agriculture is largely practised on the least productive land. For these farmers, the introduction of pump irrigation schemes represents a radical intervention. Experience shows that attempts to bring the benefits of irrigation to these poorer sectors of the rural population can only succeed if i) the schemes are simple enough for the peasants to be able to initiate, programme, execute and maintain them, ii) the peasants are involved in their conceptualization, formulation and preparation of feasibility studies, and iii) the projects take sufficiently into account the existing social structures, in particular the role of women in subsistence agriculture.

## III. NGOs' ASSETS IN SMALL-SCALE IRRIGATION DEVELOPMENT AND MANAGEMENT

Small-scale irrigation development has a number of advantages and disadvantages. These are common to both governmental and non-governmental projects and have been dealt with in other Consultation documents. This section deals only with those aspects in which NGO's may have an advantage over governments.

### III.1 Mobilization of Resources

One of the essential elements in the success of small-scale irrigation schemes is the participation of the local population and the mobilization and use of local resources. This is precisely where NGOs excel. Basing their intervention on the desire of the population to increase agricultural productivity and to improve the living conditions in the villages, they give priority in their action to support of local initiatives and are in permanent contact with the peasant reality. They endeavour to mobilize human and material resources locally available and strive to promote among the people a self-help mentality. This approach is in line with many African governments' policies aiming at promoting the self-reliance of local producers. NGO projects do not require recurring expenses from the governments and, consequently, their demand on government resources is minimal. On the contrary, they manage to bring additional funds to the service of national development. A recent report of the Development Aid Committee (DAC) of OECD* recalls that the resources mobilized each year by private organizations through all kinds of voluntary collections amount to more than two billion dollars and that official aid agencies of of DAC member countries channel through these institutions another billion dollars, i.e. five per cent of the total volume of official development aid. NGOs draw their credibility from the fact that the lightness of their structures permits these external funds to go straight to the beneficiaries and be used efficiently.

### III.2 Project Integration into the Peasant Milieu

The evaluation of many irrigation shemes shows that causes of failure stem, inter alia, from a lack of understanding of the socio-economic environment of the peasants and of their traditional agricultural practices. The approach used by NGOs' lessens this danger as it aims to start from specific actions in the villages in collaboration with local peasant associations. It thus leads to the dynamization of traditional village organizations, respecting current agricultural practices and patterns of land use. The projects build on what is already done locally and avoid radical interventions. To achieve this, NGO irrigation projects are formulated with the direct participation of the beneficiaries. In addition, they use simple water control techniques and base project management on the existing organizational capacity of the local communities.

* "Vingt-cinq ans de coopération pour le développement - un examen", OECD, Paris, 1985, p. 171.

Participation of the beneficiaries

The scale and methodology of most NGO projects facilitates participation by the villagers. In general, NGOs tend to initiate a general development process in the villages even before launching specific projects. This includes the analysis of needs and constraints, the study of possible solutions and the formulation of projects. All villagers are invited to participate in this process.

The choice of technology

With respect to the choice of technology for water development and management, NGO experience shows that it is essential to take, as a starting point, the traditional practices of the peasants and to remain as close as possible to them. Following this principle, a French NGO working in Niger, for instance, introduced a "transitional technology" (the "barrel well"), half-way between the traditional catchpits and the well built in permanent material. While this method has the advantage of testing the implications for the groundwater level, it also allows for the evaluation of the motivation of the peasants before building expensive permanent works.

This principle is particularly valid in the case of populations which have little or no previous experience with the new technology. The introduction of new technologies not only requires a learning and familiarization period, it also implies social reorganization. The Kenya report stresses that the technology should not only be such that it can easily be mastered by the peasants; it also should require only limited reorganization of labour. Such a technology assessment requires a long-term commitment and good knowledge of the social environment and, in many instances, NGOs are well placed to do it.

The relative autonomy and flexibility of NGOs and the small size of their projects, allows them more easily to introduce innovations and experiment with new techniques.

Organization and management

In small-scale irrigation projects, it is important to promote local initiatives and gradually pass the responsibility on to the village associations and groups. These groups may already exist prior to the project or be created on the occasion of its implementation. The groups must become familiar with management techniques and apply them to their specific situation. It is thus important that any training in this field takes due consideration of the local values and traditions. In some countries such as Kenya, the NGO experience in this field has led them to contribute actively to the training of the government's extension workers.

In many cases, a restructuring of traditional organizations occurs with the introduction of irrigation. Having to decide as a group how to exploit these areas brings about a redistribution of roles within the village hierarchy. When such a process occurs without conflict, small-scale irrigation projects offer the peasants a unique opportunity for strengthening community work. Given their sensitivity to the local milieu, NGOs are in a position to promote such a process.

### III.3 Multiplication of small-scale irrigation projects

A national small-scale irrigation development strategy requires the implementation of a great number of small projects scattered throughout the national territory. Enormous pressure is put on the government services if they are to provide the villages with the necessary training in order to enable the villagers to take care of the projects themselves. Government technicians and extension workers may find it difficult to ensure a continuous presence in the villages to assist the people when they need it. In addition, there are often practical problems (transportation, lodging, etc.) and financial constraints. Because of this, the valuable information of the extension service does not always reach the peasants at the right time. Moreover, often being specialized in one particular field, they manage only with difficulty to respond to the range of problems which any project, no matter how specific, poses. NGOs can play an important role in

collaborating with governments in the implementation of national small-scale irrigation development strategies. In addition, their presence in villages not reached effectively by government services allows NGOs to perform the needed extension work.

## IV. PROBLEMS ENCOUNTERED BY NGOs

This section provides a brief overview of problems encountered by NGOs in small-scale irrigation development and management. They include:

- **Excessive interference by official structures**; NGOs often mention the problem of finding a proper balance which avoids excessive interference and control by the support organization external to the village, yet provides the necessary guidance needed by the local population. Some private and parastatal development agencies exert a heavy and permanent control on the projects with the risk of discouraging the initiatives of the local producers and eliminating all aspirations to self-reliance. It would be better for the support organizations to limit their role to one of motivation and guidance and withdraw as soon as the local association is capable of taking the project into its own hands. For this purpose, it is important that the support organizations select and train members of the local associations as extension workers in their own environment. This is all the more necessary when the technical support is give by expatriate volunteers who usually stay on the project site only for a limited term. If the project depends on their advice only it will run the risk of not surviving the departure of the expatriate volunteers.

- **Lack of technical expertise**; this is the area where most NGOs are most in need of support, especially from government services. A complementary relationship should be established between the NGOs familiarity with the peasant milieu and the government services' technical capacity.

- **Land tenure**; if the landownership system is not well understood from the start, it may constitute a serious obstacle to the success of the irrigation project. The peasants need to have secure use rights or ownership of the land, if they are to invest their time and other resources in the irrigation development works. In this respect especially, NGOs would require support from the government to avoid what has happened in some cases where peasants have been evicted from land which they previously irrigated.

- **Marketing and pricing policies**; this is another area over which NGOs have no direct control and would require government support. Some NGO projects encourage, on the project site, the creation of small and middle-sized enterprises for the processing of the agricultural products. This effort requires good coordination mechanisms between NGOs and government services.

- **Coordination**; NGO reports frequently mention problems arising from a lack of, or deficiencies in, coordination among NGOs and between NGOs and government services.

- **Other problems**; these include lack of sufficient tools and equipment, breakdowns and insufficient maintenance of equipment, the covering of the recurrent costs for project operation and maintenance; lack of sufficient credit.

## V. APPROACHES TO THE PROMOTION OF NGO SMALL-SCALE IRRIGATION PROJECTS

It is in the interest of the governments that, within the framework of their national development policy, a great number of self-reliant projects managed by the local populations function efficiently in the villages without undue pressure on government structures and services.

Without generalizing and with due respect for the variety of experiences, one may say that the NGO initiatives in the field of small irrigation represent an indispensable complement to the action of the governments for the development of land and water resources. NGOs aim to give to these initiatives a community orientation, promoting the participation of the local population in the design of the projects, in the construction of the

irrigation works, in agricultural practices and in the organization of labour. This would require on their part an effort of sensitization, training and organization of the local population. It would require, on the part of the governments, the establishment of a favourable climate to NGO initiatives and the installation of coordination mechanisms between NGO activities and those of the government.

This section provides some suggestions for approaches to be adopted by national NGOs, foreign NGOs, governments and multilateral organizations with respect to the promotion of NGO small-scale irrigation projects.

a) **National NGOs** must develop their capacity to support village initiatives within the framework of a development programme. Their role is to create a bridge between the felt needs in the villages and the motivations of the peasants in undertaking development actions, and the government services mandated to respond to these needs but often unable to ensure a permanent presence in the villages.

b) **Foreign NGOs** should preferably work together with national NGOs rather than launching their own projects in the villages. They have an important support role to play, particularly in assisting local and national NGOs in the design of development programmes. Funding agencies should adopt a flexible funding policy vis-avis small-scale irrigation projects and it may be necessary to prolong the disbursement period beyond the usual practice, because encouraging people's participation in the identification and formulation of a project is a very slow task. Consequently, programme costs tend to rise. Execution costs however tend to diminish since these projects rely on a maximum use of local resources. A relatively large proportion of funds has to go to the sensitization, training and organization of the local population as essential conditions for their participation in the implementation of projects. This will carry extra institutional and administrative costs. The process of choosing and financing the appropriate irrigation technology might also take longer and require a deeper commitment with the local population than the mere provision of equipment without looking at its social impact (the "quick-spend-and-go" approach).

c) **Governments** would need to establish an environment favourable to the success of small-scale irrigation projects. This implies a credit policy encouraging local initiatives, accompanied by a favourable price policy (especially in the case where private or parastatal agencies exert a total control on the commercial circuits, thus reducing the profit margins of village producers deprived of direct access to the market). It also implies a land tenure policy which allows access by village groups to the land to be irrigated. Finally, governments should look positively at the emergence of informal village associations taking charge of projects, and ensure that the statal or parastatal government agencies will not suffocate their initiatives, but rather help them reach self-reliance by providing them with technical advice and assigning cadres for flexible coordination.

d) **Multilateral organizations** have an important role of technical support to play towards NGO small-scale irrigation projects. These organizations have the possibility of acting, together with their member governments, on the wider issues on which the NGOs themselves may have no grasp, such as commercial policies, or the local processing of the products.

They also could engage in discussions with governments on the importance of the role of peasant organizations and village associations sufficiently trained and equipped to take responsibility for small-scale irrigation projects within the framework of the governments' national development strategies. By maintaining relations not only with governments but also with NGOs, multilateral organizations may play an important role in helping to avoid, on the one hand, that village associations lose their autonomy in the face of huge operations launched by the governments and, on the other, that the small projects, scattered throughout the country, go their own way without beneficial integration into a coherent national policy.

The activities of FAO in support of NGO small-scale irrigation may be cited as an example of the openings for multilateral organizations in project formulation and funding, technical assistance and the diffusion of experience.

- Through FFHC/AD,* FAO helps African NGOs and village associations to formulate locally-based projects, providing not only material inputs but also the necessary assistance in training and monitoring. These projects are funded by Northern NGO donors. Twenty-one such projects were finalized and funded in 1985 for a total donor contribution of almost US$ 1 million. Over 200 projects in 15 African countries are currently in the pipeline.

- FAO provides technical support to these NGO projects, drawing on field project staff, on the staff of regional offices or on consultants. Effective coordination of material and technical assistance is thus ensured and an outreach to small producers is provided for national level projects.

- A handbook describing and drawing on lessons from NGO experiences in small-scale irrigation in Africa is under preparation. Its purpose is to identify the key factors in the success and failures of projects and to offer guidelines on how to solve frequently encountered problems.

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* FFHC/AD: Freedom from Hunger Campaign/Action for Development

Doc. III-B (4)
(Original in English)

# DISEASE CONSIDERATIONS IN WATER DEVELOPMENT FOR AGRICULTURE

**SUMMARY**

In a majority of countries in Africa, there is a background health problem which includes various water related diseases. Among these are the vector borne diseases, including malaria, schistosomiasis, lymphatic filariasis, and those where the pathogen is generally a component of drinking water, such as the diarrhoeal diseases, cholera, typhoid and dysenteries.

The development of water resources, with the associated modification of the aquatic environment, influences the risk to human health. Where the changes involve an increase in susceptible populations and closer, more frequent contact with disease vectors or contaminated water, development should be accompanied by appropriate measures to offset the health risk. These may incorporate prophylaxis, chemotherapy, chemical control, environmental manipulation and modification, sanitation and water supply. Usually a combination of measures will be needed, together with community education.

The majority of these techniques have been put into practice in a wide variety of conditions, and offer prospects for combating the negative health effects that may otherwise accompany water development for agriculture, notably irrigation and drainage. It should also be realised that well planned water development can in fact contribute to a reduction of health risk within the community.

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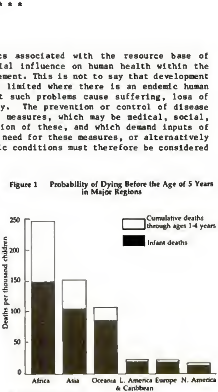
## I. THE HEALTH PROBLEM

The physical and climatic characteristics associated with the resource base of Africa also provide an environment with potential influence on human health within the context of water resources development and management. This is not to say that development processes should be discouraged or deliberately limited where there is an endemic human disease problem, but it must be recognized that such problems cause suffering, loss of life and economic loss due to lower productivity. The prevention or control of disease therefore requires the introduction of specific measures, which may be medical, social, institutional or physical, and often a combination of these, and which demand inputs of manpower, equipment, materials and finance. The need for these measures, or alternatively the acceptance of the degraded social and economic conditions must therefore be considered a constraint on resource development.

From Fig. 1, it is clear that there is in the majority of countries of Africa a background health problem which calls for attention in any form of development programme involving the movement or settlement of populations. There are also various diseases which are susceptible to a rapid increase in prevalence as a result of environmental and human population changes. It is these which create the main health risks associated with the development and management of land and water resources. They include the vector-borne diseases such as malaria, lymphatic filariasis, arthropod-borne viruses (arboviruses), onchocerciasis (river blindness) and schistosomiasis, in which the transmission chain includes an insect or, in the last named a snail. To these may also be added the water-borne diseases in which the pathogen usually, or frequently, enters the body as a component of drinking water. Among them are the diarrhoeal diseases, cholera, typhoid and dysenteries.

Figure 1 Probability of Dying Before the Age of 5 Years in Major Regions




SOURCE: WHO (1978)

Considering first the vector-borne diseases, these are widely endemic in Africa. Malaria transmission occurs in all countries between the approximate latitudes of 20°N and 25°S, with some pockets of limited risk outside these limits. Lymphatic filariasis, also transmitted by mosquitos, is endemic between about 15°N and 20°S. Schistosomiasis is evident in virtually all African countries, but presents a problem particularly in those immediately south of the Sahara and in east and central Africa below the equator. The Nile Valley has, from historic times been severely affected by schistosomiasis.

## II. THE IMPACT OF DEVELOPMENT

The intensification of these diseases is usually due to a combination of causes which include large increases in the numbers of the vectors, a susceptible human population and greater opportunity for human/vector contact through modifications to economic or social activities. These circumstances usually arise through induced changes in environmental or ecological conditions which influence the vector habitat, particularly the aquatic component which is essential to the survival and breeding of mosquitos, simulium (blackfly, the onchocerciasis vector) and snails. Examples of this include water impoundment, water diversion and irrigation development.

The introduction of large-scale irrigation or drainage often leads to greatly reduced biological diversity, and one of its effects is that it usually provides ideal conditions for population explosions of a few plant and animal species. In other words problems with pests and weeds arise. The exact changes in pest status of mosquitos, snail intermediate hosts of schistosomiasis, rodents, birds, weeds, etc. caused by irrigated cultivation will depend on a variety of factors including the original fauna and flora, the new habitat being created, its management, and nearby non-irrigated areas.

Some of the changes that can occur due to irrigation projects are illustrated by the Ahero rice irrigation scheme in the Kano Plains of Kenya, where mosquitos in two villages were studied. One consisted of a newly established village on the 800 ha irrigation scheme, while the other was an older village situated in a non-irrigation area where traditional mixed agriculture was being practised, and where there were assorted ground pools, borrow pits, and marshy areas. In the older village in the undisturbed area 99 percent of the mosquitos biting people comprised Mansonia species (vectors of lymphatic filariasis and Rift Valley fever), and less than one percent were of the Anopheles Gambiae complex which includes the principal malaria vectors in tropical Africa. In marked contrast, in the irrigation village the incidence of Mansonia biting was only 28 percent, of which Anopheles Gambiae complex constituted 65 percent, while about 5 percent of the catch consisted of Culex quinquefasciatus another lymphatic filariasis vector (these were not breeding in the rice fields but in polluted waters associated with the village itself). Such changes can sometimes increase malaria and filariasis transmission and introduce new arboviruses but the degree of change will vary from area to area.

Malaria is the most important of all vector-borne water related diseases, and of a world total of more than a million deaths caused annually most are in tropical Africa where more than 200 million people live in areas unprotected by any specific anti-malaria measures. The control of malaria and of the mosquito vectors of this and other diseases is hampered by increasing resistance to drugs by the Plasmodia parasite and by an even more dramatic resistance to insecticides on the part of the mosquito. This results from the survival of individuals subjected to exposure to agricultural and other pesticides, and their subsequent successful and rapid reproduction. Because of this, it is necessary to adopt an integrated approach to control, which combines prophylaxis, chemotherapy, and chemical control with appropriate environmental measures incorporated in land and water developments in areas where mosquito-borne diseases are endemic. It should be noted that environmental design of settlements, housing and services, especially settlement drainage have an important place in such measures which are aimed at reducing potential breeding sites of mosquito vectors.

Schistosomiasis is predominantly associated with irrigated areas, but natural waters commonly provide the snail intermediate host with suitable habitats and serve as transmission sites in endemic areas. Overflows due to floods, and water seepages lead to the formation of marshes, swamps and pools which provide additional snail habitats. Human

interference, in the form of water storages, irrigation canals, fish ponds, drains, culverts and crossings often create an evan more suitable environment for the snail hosts of schistosomiasis.

The relationship between water developments and schistosomiasis in Africa is well illustrated by Table 1:

Table 1 - Examples of Increased Prevalence of Schistosomiasis Resulting from Water Resource Development Projects

| Country | Project (Year completed) | Pre-project prevalence (per cent) | Post Project prevalence (per cent) |
|---|---|---|---|
| Egypt | Aswan Dam (first) (1900) | 6% | 60% (3 years later) |
| Sudan | Gezira Scheme (irrigation) (1925) | 0% | 30-60% (15 yrs later) |
| Tanzania | Arusha Chini (irrigation) (1937) | low | 53-86% (30 yrs later) |
| Zambia and Zimbabwe | Lake Kariba (1958) | 0% | 16% adults<br>69% children<br>(10 yrs later) |
| Ghana | Volta Lake (1966) | low | 90% (2 yrs later) |
| Nigeria | Lake Kainji (1969) | low | 31% (1 yr later)<br>45% (2yrs later) |

Source: Rosenfield, P.J. and Bower, B., 1978

Snail habitats are very varied and no single environmental method can eliminate them all. Each species may require individual attention to select the most appropriate approach. In studies in Egypt, Biomphalaria, the host of S. mansoni, was found to be most abundant in drains, especially in association with water hyacinth, Eichhornia crassipes. On the other hand, Bulinus, the host of S. haematobium, was most abundant in large canals, decreased towards the drains and was uncommon in the presence of water hyacinth, although populations of both snails were largest where vegetation was abundant. This illustrates the need to identify the specific forms of disease in a given area, and to devise approaches and concentrate efforts accordingly.

## III. HEALTH PROTECTION - EXPERIENCE AND PROSPECTS

Only recently safe, effective and low cost drugs have become available for treatment of all types of human schistosomiasis. The new antischistosomal drugs, oxamniquine, praziquantel and metrifonate, are used on a large scale in most endemic countries and treatment with these drugs is now the first line of attack in schistosomiasis control programmes. These drugs can be given in the endemic communities, with medical supervision by paramedical personnel.

But the current emphasis on treatment of infected people must not be misinterpreted to mean that there is no place for snail control. On the contrary, now more than ever before, snail control measures undertaken immediately preceding or concurrently with large-scale use of chemotherapy may cause a dramatic reduction in transmission as well as the expected reduction in prevalance and number of parasites in the population.

In effect, this calls for chemical control with molluscides, improved environmental design and environmental management. Recent concern over pollutants is leading to the promotion of more general environmental measures, with chemical control directed at a few susceptible focal points.

Environmental design can be grouped under two headings. The first concerns the prevention of contamination of water, the second involves the physical separation of people and water which is infested by the cercariae which cause infection by penetrating the skin of the human host. This first heading, sanitation, aims at providing adequate and acceptable facilities for excreta disposal so that schistosome eggs evacuated from a human, and which release the cercariae, cannot reach water with which other people will come into contact.

The second heading, housing and water supply, is also intended to cover actions which will prevent human contact with cercariae. These measures include siting of housing away from canals, provision of adequate and safe water supply, protection of surface water by covers, pipes or fencing, provision of protected facilities for bathing, water recreation and laundering, and similar measures to reduce human contact with cercariae-infested water.

The subject of drinking water supply deserves special mention. Although drinking water is not a major route of infection, the collection of water from infected sources, and associated human contact is a distinct risk. The removal or destruction of cercariae from treated water is completely feasible and, since the failure of the cercariae to penetrate a host wihin 48 hours means their death, the storage of drinking water is sometimes used to advantage.

All vector snails require water, at least for breeding. The management of water bodies is therefore, potentially, a powerful method of control. In the environment of the irrigated field there are opportunities for vector control by changing the aquatic habitat of the snail, but these opportunities must be seen in the light of farming requirements to achieve maximum crop production. The subject is therefore a complex one, with many site specific variants and constraints.

A major approach to control aims at preventing the creation of unnecessary water bodies such as depression pools or seepage areas below storages or canals which may require local drainage or land-fill together with regrading to facilitate surface water run-off. To this should be added measures such as irrigation canal lining or raised flow velocities where practicable to discourage the attachment of snails to surfaces of water courses or to aquatic weeds. These latter present a widespread problem, especially in drains where a high nutrient content and slow flow encourage plant growth. Weed clearance is therefore an important control measure in many schemes.

An epidemiological study of the Yagoua rice scheme in North Cameroon showed a strong correlation between snail populations and aquatic vegetation. Among natural habitats, the channel of the Logone River, which is sandy with little vegetation, was not suited to the development of gastropods, but the "mayos" (intermittent watercourses, partly dry with pools in the dry season) were more suitable. The Mayo Guerléo in particular, which bordered the rice fields and received their drainage water, had abundant aquatic vegetation which provided excellent conditions for the many mollusca living there. The small seasonal ponds, in clayey basins, disappeared entirely during the dry season. They were seldom colonised by plants and only rarely sheltered molluscs.

The artificial habitats studied were the irrigation canals, the drains, the rice field itself and the downstream lake contained by a dyke. The irrigation and drainage channels, which dried almost completely for about two months between the dry season crop and the rains, still provided the means of survival in low spots with stagnant water, especially in secondaries and tertiaries, which were colonised with Oriza barthii (wild rice) and Echinochloa stagnina (wild millet) as dominant plants. These plants provided an excellent habitat for snails, and populations varied according to the state of channel maintenance which was carried out by grader every two or three years. This channel cleaning briefly suppressed the aquatic and bank vegetation and destroyed a large proportion of the snail vector population in canals and drains, which are used by the local population for domestic activities and fishing.

In planning the control of vector-borne diseases in irrigation schemes, it is necessary to consider the diversity of vectors and of the habitats best suited to their

production in order to develop the specific measures to prevent or limit their spread and their contact with the local population. There are, however, some approaches which can be expected to give benefits in relation to most of these diseases.

Briefly, they can be presented in three groups: improved water management, achievable through suitable design, construction and operation of the hydraulic system, coupled with properly adapted cultivation practices to prevent unnecessary residual water bodies or other potential environmental hazards in the irrigation system, the field or the drains; community education to teach the causes, effects and means of preventing disease through personal protection and group initiatives aimed at providing better settlement services; community health facilities with supporting staff, administration and the mobility to implement prophylactic and curative programmes and any required emergency measures to avoid or contain the risks of epidemics.

With regard to water-related diseases other than vector-borne, agricultural development often provides opportunities to improve the conditions for community health by incorporating safe drinking water supply and sanitation. Unfortunately these opportunities are frequently neglected because of their cost which is regarded as a constraint on the primary purpose of development where this is, for example, agricultural or industrial production. This is especially common in rural areas where there has long been customary use of unimproved water sources.

Amoebiasis, typhoid and diarrhoeal diseases can be significantly reduced by safe water supply and sanitation, as can many other diseases. Adequate water supplies for bathing, washing of clothes and cooking utensils, food preparation and other hygienic purposes can also have marked effects on diseases of the eyes, skin, food-borne diseases and others (see Table 2).

Table 2 - Estimated Proportion of Preventable Water - Related Disease in East Africa in 1966

| Diagnosis | Percent Reduction Expected if Water Supply were excellent | Diagnosis | Percent Reduction Expected if Water Supply were excellent |
|---|---|---|---|
| Guinea Worm | 100% | Tinea | 50% |
| Typhoid | 80 | Gastroenteritis (4 wk to 2 yr) | 50 |
| Urinary Schistosomiasis | 80 | Gastroenteritis (over 2 yr) | 50 |
| Leptospirosis | 80 | Skin and Subcutaneous Infections | 50 |
| Trypanosomiasis, gambiense | 80 | Diarrhoea of the Newborn | 50 |
| Scabies | 80 | Paratyphoid and other Salmonella | 40 |
| Yaws | 70 | Louseborne Typhus | 40 |
| Inflammatory Eye Disease | 70 | Intestinal Schistosomisis | 40 |
| Schistosomiasis, unspecified | 60 | Ascariasis | 40 |
| Trachoma | 60 | Louseborne relapsing fever | 40 |
| Bacillary Dysentery | 50 | Otitis Externa | 40 |
| Amoebiasis | 50 | Classic skin (leg) Ulcer | 40 |
| Dysentery, unspecified | 50 | | |

Source : White, et al (1972)

The development of water resources for irrigation and other agricultural purposes, while perhaps introducing an increased risk to health in disease-endemic areas, also offers the chance of ameliorating health conditions through providing better services to the community. The task of the planner is to ensure that the development process takes into account both the positive and the negative impacts, and applies the most appropriate measures in the overall plan.

**REFERENCES**

1. Rosenfield, P.L. and Bower, B. The Incorporation of Health Parameters into Engineering Design. Resources for the Future, Washington 1978.

2. White et al. Drawers of Water. Domestic Water Use in East Africa. University of Chicago 1972.

3. WHO. Report of International Conference on Primary Health Care, USSR 1978.

Doc. III-B (5)
(Original in English)

# LAND TENURE AND IRRIGATION DEVELOPMENT

SUMMARY

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**SUMMARY**

Certainty about tenure and water rights is essential if people are to invest in the equipment needed for irrigation. Ownership is generally linked with responsibility for maintenance. When land, irrigation facilities and labour are provided by different parties, all parties need to agree on who has obligations to maintain, and how costs aod profits are divided. This clarity is often lacking in many African countries. Central governments are not sufficiently aware of the degrees to which customary law provides protection for improvements. The imposition of new statute law, not always enforced, creates uncertainty.

A common model in government-controlled irrigation is the settlement scheme io which the irrigator has only a one year tenure, and the land, in the view of the government, belongs to the state. The government imposes cropping, patterns and practices, and deducts sums from the tenant, while not always maintaining the facilities. The tenant feels no commitment to invest in land improvement, or to provide labour for maintenance, and cannot adjust the size of the holding to family needs and capabilities. The full production potential of the scheme is seldom met. Costs for staffing are high, particulary in the smaller schemes with no economics of scale.

About 45% of African irrigation has developed under customary law. The main constraint has been inability to get credit from the formal sector, since land titles are not legally recognised as security for loans. Another constraint has been the failure to recognise the water rights of those who develop their own farm or group scheme, and some farmers have lost the fruits of their investment as a result of government projects upstream.

When the large settlement scheme is popular with tenants, a few modifications may improve efficiency: giving tenants a longer lease, recognising transfers between tenants or to new entraots, giving blocks of tenants a say in crop choice, clarifiying which parastatal or organisation owns what facilities, and accounting to tenants for the operation and maintenance costs which they pay.

On new large schemes existing land rights need to be recognised and either compensated, or preserved. This is particularly important in densely populated areas, where the cost of compensation, and the land lost to reservoir areas, should be carefully appraised.

In medium sized schemes, the settlement system is not necessarily appropriate. Alternatives are Asian-type schemes, or commercial or state farms.

Schemes under 500 ha may be considered for transfer to farmer ownership as soon as possible as they are not usually economic under government maoagement. However, farmers taking on responsility for maintenance and operation will need legal titles and rights, or they will not be able to enforce their regulations on their own members, or to sue outsiders who damage their facilities. Where freehold titles cannot be giveo governments could consider long leases as an alternative.

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## I. IRRIGATION, LAND TENURE AND WATER RIGHTS

### I.1 Linkages

Land rights take different forms in different societies and may derive either from custom or from written law. What is important is who, in practice, has the right to control use of land, for how long, and how secure this control is. If persons have the acknowledged right to control use during their life and to pass this right on to their heirs, their behaviour is similar to that of an owner under freehold. Ownership is associated not only with control of use, but also with responsiblity for maintenance of

the land and any improvements on it. Irrigation is a form of improvement involving control of water, so clarity in rights to water is important.

In the simplest situation, one person or household owns both land and equipement for water control. Where irrigation covers more than a few hectares, it is common for individuals, groups or communities, commercial suppliers, and state governments to be involved at different levels or in different elements. In the more complex cases, it is essential to have clarity and agreement between the parties involved on who owns what, who therefore has obligations to maintain, who receives a share of the rewards, and who contributes to the costs of construction, maintenance and replacement. Without this clarity good management by any party involved is impossible. Unfortunately, this clarity and agreement are often lacking in two common types of African irrigation development: private sector development, particularly under customary law, and government development on settlement schemes.

Water rights are often not clear. Water law and custom need to change as water becomes scarcer. It becomes necessary to know what is being withdrawn from rivers or groundwater, to register users, ration the supply if necessary, and licence new developments. A principle has to be adopted that will decide priority and preserve the rights of those who have invested in water development, while allowing governments to tighten up water use and spread the resource to more people as development proceeds. The absence of monitoring and consequently, of a system allocating secure rights to users within the available supply, will become an increasing handicap. It would be necessary to bring in the local authorities if any system of monitoring and licencing boreholes and wells is developed, since they would be accessible to small rural developers, and are the most likely level of government to have the means to check on developments.

### 1.2 Tenure Arrangements in Sub-Saharan Irrigation

About 60% of Sub-Saharan irrigation is under various forms of private tenure, with about 45% deriving rights mainly from traditional custom and 15%, mainly comprising larger-scale operators, usually operating under modernised statute law or special legal concessions (Ref.1). The percentage in the private sector is likely to be understated since governments may report state land once equipped with irrigation facilities as currently irrigated even if it has fallen out of use, while the private sector does not always report land improvements.

Of the 40% of Sub-Saharan irrigation which is in the public sector, just over 30% is managed under a "settlement scheme" model deriving from the Gezira in the Sudan in which government is owner or controller of the land, and farmers are tenants having only an annually renewable lease which is subject to control on crop choice, crop management and marketing. In addition, government agencies may supply not only water but also other essential agricultural inputs and services.

### 1.3 Conflicts between Private and State Views of Land Tenure

Customary tenure has not impeded irrigation development. What can act as a constraint is conflict between central government and local views on ownership, since this reduces the security which is a precondition for investment. Conflict is becoming increasingly common. The source of the conflict is failure to realise the flexibility of African customary tenure and the way it evolves under changing conditions of population pressure, increased access to markets, and the greater possibility of sales of agricultural produce. Within any one country there may be areas where communal authorities still exert control over access to land, and other areas where land has become individual property that is inherited, sold, leased, pledged, etc, irrespective of national law. Governments frequently do not realise that the change has taken place. Nor do they always realise that the so-called communal systems provide security for investment by recognising individual rights to improvements, rights to transmit land to heirs, and rights to continued occupancy during usage. At the same time mechanisms such as gifts and loans enable transfers to be made between families short of labour and families short of land.

In some countries, nationalisation of land has been introduced, but this may not affect local practice. In others, land has sometimes been registered as private property,

to promote willingness to invest in land improvement. However, in many districts and in entire countries land-holders with customary rights do not enjoy full recognition by new types of local government, or by national courts, or by credit institutions and banks. This can easily result in:

- serious errors in planning and implementation of large schemes, where the realities of the rights of existing land operators have either to be compensated at unexpected cost, or are over-ridden by harsh measures which ensure that the population views the scheme with hostility;

- disincentives and barriers to land improvement by the ordinary rural farmer.

## 11. CONSTRAINTS ON IRRIGATION DEVELOPMENT

### II.1 Development by Individuals under Customary Tenure

The two main types of irrigation development by individuals under customary tenure are: i) various forms of pumping from streams or shallow wells mainly for vegetable cultivation; the systems may be manually operated, but increasingly, petrol or diesel driven pumps are being used; and ii) various forms of partial water control on flood recession land, valley bottoms, etc. Crops include rice and sugarcane.

In areas where vegetable cultivation is profitable, commercialisation and population density have usually ensured that tenure has evolved to the stage where people have secure rights to land, at least so long as they use it. Often there are also recognised contractual practices regarding lending, leasing, sharecropping, pledging, sales, etc. Normally landowners operate their own equipment, but they may also provide the equipment, or the water it generates, to others in return for services, goods in kind, or cash. Similarly, they may buy or lease land to get full use out of their equipment.

In the case of flood recession land, there may still be an element of control by communal authorities, particularly in areas of low population density, or isolated from markets.

Constraints on development may include the following:

- land can seldom be used as security for a loan from modern credit institutions, since the land title is not recognised as good for this purpose. Irrigation equipment is usually financed from the sale of assets (e.g. cattle), or loans from family, village money lenders, traders, etc. This may imply that a tenant purchases a smaller or less efficient item of equipment than would be desirable, or make it difficult for poorer farmers to get started;

- farmers who have invested labour in the cultivation of flood recession land may have found their effort complicated by other development actions. The level of groundwater may change, due to either over-exploitation in the absence of laws regulating or licencing groundwater use, or because of changes in river regime due to government projects. Government laws on soil conservation may be over-cautious in preventing peasant use of stream water or swamps while giving riparian rights to large owners. Such uncertainties do not encourage investment and innovation;

- sudden change in the technology available may create demand for uncultivated land which traditional village leaders still control. They may sell or transfer rights to larger farmers, commercial operators or to government parastatals without consulting the community in general. The resultant hostility from local farmers who feel themselves deprived of rights and opportunities has caused considerable problems to schemes in Ghana (Refs. 2 and 3).

Government attempts to change the law to improve the incentive for investment have sometimes been successful, but had unexpected unfavourable repercussions on the poorer sections of rural communities. The uncertainty created by a new law may reduce willingness

to make the loans or leases which customarily enable the landless or the stranger to get eccess to e lend resource. Wealthy, literate outsiders may seize opportunities et the expense of land users relying on custom. This has been reported in Senegal since 1980, where e law intending to remove control by elite groups, and to allocate land to those who use and improve it has enabled some entrepreneurs to see that the purchase of a pump gives them land rights (Ref.4).

### II.2 Group Development under Customary Tenure

There ere two main types: i) swamp development, and other partial control systems, often involving dyking; this is particularly common in west Africa, for rice cultivation; and ii) canal systems, found in eest and southern Africa; these community built systems are not officielly called "canal systems", which might imply recognition of the legal rights of the constructors, but are referred to as "furrow" systems.

In both, group work is necessery for construction and plenning. Within the system, land may either belong to the original owners, or, if new land is being developed, be allocated to those contributing work and leadership. Inheritence follows customery patterns. Ferm menegement is by individuals or households, with e minimum of community rules.

The constreints on privete group development ere the seme es on privete individuel development. However, in addition:

- the group has sometimes even less legal status than the individual, and may be less able to borrow money from modern financiel institutions. It may be able to pool cash contributions for construction, but financial planning and provision for meintenance and replecements can be very difficult without a bank account. In consequence, the level of technology is usuelly low and is limited to whet cen be creeted by human lebour from locel resources (unlined canels, eerth embankments, etc.);

- given the uncertain status of both group property in the equipment, and individual property in the lend, the community is often unwilling to ask government for technical or financial help, for fear of losing control over its assets;

- the lack of protection or even ecknowledgement of community rights in their construction is unlikely to promote community self-help.

### II.3 Private Operators

Modern private operators may be either large or small scale. The former may well be operated by companies, as with the Triangle and Hippo estetes in Zimbabwe (eech ebout 12 000 he). The letter mey be opereted by individuals end be anything upwards of 10 ha. African commercial fermers ere increesingly ective in this sector. Sprinkler systems ere common. In Zimbabwe many commercial farmers construct their own small storage dams and weirs, sometimes with finencial essistance from government through the Agricultural Finence Corporetion (Ref.5). Government has also constructed some major dams and reservoirs; farmers using water from these pay towards the investment cost through a water rate besed on their water right. Water rights ere registered end protected. Kenya has similar legislation; private commercial irrigation expanded by 6 000 ha to 15 000 ha 1973-1978, while government schemes expanded by 3 000 he to 10 000 ha (Ref.6). These systems ere characterised by certainty over rights in land, which cen be used es security for loens. There is also certainty about the ownership of equipment, end there is usually assurence of continued water rights.

## III. ALTERNATIVE TENURE SYSTEMS FOR IRRIGATION DEVELOPMENT

The eppropriete tenure and management system will depend partially on size, and size is governed by technicel and economic considerations. Essentials in any irrigated tenure system are:

- clerity end constrectuel agreement between ell parties on ownership, end responsibility for maintenence of lend end equipment;

- control and decision making linked to ownership;

- security of tenure at least for the life of the equipment.

III.1 **Existing Large Settlement Schemes**

If the existing tenure system, and the income derived from it, are on the whole acceptable to the people concerned, the only question is whether any modifications might increase ability to meet changes in the economic environment, and reduce government costs.

If the system is not satisfying the tenants on grounds of income, or the government on ability to meet recurrent costs out of revenue, more drastic changes may need to be considered. Would any of the management modes suggested for medium scale systems (Sect.III 2) work, if the system could be divided into areas with separate water inlets ? Is it really worth maintaining the system, or should it be written off ?

The following are some possibilities for modifying tenure on large, relatively popular systems. It is important that any changes be preceeded by consultation and assent, signalised by a visible ceremony or documentation, so that all concerned are informed of their new legal reports and duties:

- introduction of greater flexibility in cropping, and more rapid adjustment to market changes, even if the design makes individual choice impossible. In the Gezira, different blocks already grow different cotton varieties with different water requirements, as decided by management. It should be possible for tenants to vote on a block by block basis for different combinations of technically feasible crops. Such a change is practical, as the former system of paying recurrent costs out of a share of the cotton crop has been replaced by a land and water charge on each crop. The right to an increased say in crop choice could be negotiated in return for increased tenant responsibility for maintenance or operation of specified block equipment, which might reduce government costs;

- tenancy, in course of time, becomes officially or unofficially heritable, and at least temporarily transferable to other hands. There are advantages to recognising these practices and giving them full legality. If the state does not wish to give freehold in land, the basis for the tenancy could become a long lease (20, 40, 100 years). This would enable elderly tenants, or those who had developed other interests, to sell out to those who have a genuine interest in earning an income by farming. It would make it legal for families to sub-let land, according to their abilities and the size of their labour force. It would solve the problem of improvements on the land such as housing, as a tenant could transfer these with his lease;

- specified irrigation facilities, for example secondary and tertiary canals, could be owned by the parastatal responsible for management. Other structures, for example secondary and tertiary canals, could be owned by the parastatal responsible for management. Other structures, for example storage reservoirs and large dams, might belong to the central government, with the parastatal drawing specified quantities of water for a fee. Farmers pay for the use of the facilities directly to the parastatal, which would have to manage operation and maintenance within its budget. The central government could decide whether to subsidise the use of its structures. The Board of Management of the parastatal should include farmers' representatives. Some elements of this strategy already exist in some management systems.

III.2 **New Large Systems**

If new large systems are planned, the following should be considered:

- it is important to ascertain existing land use, land rights, the productivity of land and water, and the cost of fair compensation for disturbance, before deciding to embark on the scheme;

- if the land is already occupied, and holdings are small, it is possible to leave land titles undisturbed. This seems to have worked for the Kano River schemes in Nigeria (16 500 ha in use). It means government staff have to adapt to the role of advisers and suppliers of services. If holdings are large, as may happen in some rainfed systems, it may be advisable to impose a development charge on the owners, to encourage them to sell or rent out what they cannot manage themselves under the more intensive cultivation system that irrigation requires.

### III.3 Medium Scale Systems

The settlement system is not necessarily the best model, particularly below 5 000 ha. Options are:

- in lightly populated, mainly unused land, the state may decide to buy out existing rights and set up a state farm. This has the advantage that rights, responsibilities and profits, if any, are all concentrated in government hands, and employees have a clear understanding of their position, rewarded by wage. This option should, however, only be considered if there is successful experience of managing state farms in the less demanding rainfed sector, and if there is an adequate supply of capable, dedicated managers. A variant is the core estate with outgrowers. In this case, the outgrowers need clear titles to their land and clear contracts with the core estate. A core estate can suffer the same problems as settlement schemes, with tension between the interests of management and farmers;

- possibly preferable is the commercial estate, with or without a government shareholding. It is likely to investigate feasibility carefully, and will keep staff and other costs under control. It requires freehold land or a lease for a definite period of years, and a defined, guaranteed water right. It is desirable that the commercial organisation pay for and own at least the on-scheme irrigation facilities, and contribute to the cost of water supply. Since it takes commercial risks, it should have responsibility for deciding crop patterns and markets, and the right to vary these if conditions alter. As the management will be responsible for making a profit, it should be left to them to decide how they can attract labour - whether as employees or as sharecroppers or sub-lessees.

### III.4 Existing Small-Scale Settlement Schemes

These schemes usually run at a loss and absorb a disproportionate amount of government staff and resources. One possibility is to turn the schemes over to farmer management. They are more likely to succeed if government has the capacity to give them appropriate training and advice in financial management, maintenance procedures, etc. Experience shows farmers are capable of managing small systems. The example in Zimbabwe has already been quoted. The village schemes on the Senegal River are another well known example. Farmers Association schemes also operate successfully in Swaziland, although similar sized government-provided schemes suffer poor maintenance and poor utilisation (Ref.7).

It is essential that if schemes are handed over to farmer management, the group be given legal tenure of the land and equipment, including any facilities outside the scheme area, such as a feeder canal, either in perpetuity, or for at least 20-30 years. The legal rights to the land and equipment should preferably be handed over ceremonially and visibly, and registered with the appropriate local authority. The group will need to be able to defend its property against damage, e.g. by outsiders' cattle, by suing offenders in the local village or district court. If the group has legal tenure and a recognised legal constitution, it will also be able to make legal agreements with its own members, subleasing them their plots on a long tenure.

There is a need to clearly define responsibilities with cooperative management between parastatal and farmers. If farmers are expected to manage a scheme themselves they must have power to decide who to employ, the terms of service and whether to economise on staff requirements by doing maintenance by communal work.

### III.5 New Small-Scale Schemes

Governments may consider it useful to support the construction of small-scale schemes for farmers only if a group has already been formed, which is ready to commit land, labour and capital to the enterprise. An exception might be the construction of a model scheme in an area where there is potential for its replication. The SAED village schemes started with two model schemes in 1974; the remainder were initiated after requests from other villages, who contributed land, labour and some cash, with SAED providing technical guidance and some mechanical services, (Ref. 8). In Swaziland, on the Farmer Association Schemes, farmers provide labour and a significant proportion of the capital. The Irrigation Branch of the Ministry of Agriculture has sometimes provided a design, detailed specifications, and some capital (Ref.7).

### III.6 Private Sector Development

Private sector development, large or small, group or individual, might be encouraged by the following measures:

- land reform, providing customary holders with secure titles. However, this should be approached carefully. Customary tenure does not prevent irrigation development; it merely forces developers to rely on savings and informal credit sources. It does not prevent farmers who invest in pumps from renting additional land, but as long as this remains an activity not recognised by central government, it may make them reluctant to go to government departments for advice. Changes in land law often cause economic disruption and some loss of agricultural production. With a well designed reform the period of disruption is likely to be short and benefits soon start to flow. Ill-considered laws that have to be modified or withdrawn after a few years, or which are only partially enforced, create the uncertainty over land ownership that is a real threat to any kind of investment in land improvement. It is preferable that the same tenure rules apply to irrigated and unirrigated land;

- strengthening the capacity of the Ministry of Agriculture or Irrigation, as appropriate, to give advice on scheme design, maintenance routines and financial management to individuals or groups who want to set up their own systems;

- assisting and strengthening the management capacity of groups. Again, this is something to be approached with caution. Farmers will often prefer, where feasible, an individual approach, e.g. someone buys a pump which she lets others use on a variety of terms. Even the other users may find this more satisfactory than trying to manage the asset jointly, with doubts about who is responsible for getting spares, etc. In some countries and circumstances formal co-operatives may work; in others, smaller, less formal groupings based on existing village associations like mutual credit groups may be preferrred. It would be helpful if the less formal groups could register their status with their local government authority, and receive legal recognition as a group, able to apply to formal sector credit organisations. When, as in Kenya, there is a well-established community development organisation, this organisation could give valuable advice to self-help irrigation groups.

### REFERENCES

1. FAO (1985) - Irrigation in Africa South of the Sahara: A Study with Particular Reference to Food Production. Report No 111/85, Rome.

2. Goody, J. (1980) - 'Rice-Burning and the Green Revolution in Northern Ghana'. Journal of Development Studies, Vol 16, No 2.

3. Konings, P. (1981) - Peasantry and State in Ghana: The Example of the Vea Irrigation Project in the Upper Region of Ghana'. Working Paper No 5, Leiden, The Netherlands: African Studies Centre.

4. Mathieu, P. (1985) - 'Agriculture irriguée, réforme foncière, participation paysanne: Le cas de la zone de Guiers dans la vallée du fleuve Sénégal', in ed. G. Conac et al, les Politiques de l'Eau en Afrique, Editions Economica, Paris.

5. Mupawose, R.M. (1984) - 'Irrigation in Zimbabwe, a Broad Overview'. Insert in ed. Blackie, M., African Regional Symposium on Small Holder Irrigation. Hydraulics Research Limited. Wallingford, England.

6. Toksoz, S. (1981) - An Accelerated Irrigation and Land Reclamation Program for Kenya: Dimension and Issues. Development Discussion Paper 114. Harvard Institute for International Development, Harvard University.

7. Funnel, D.C. (1986) - Small-Scale Irrigation on Swazi Nationaland. Draft typescript, University of Sussex, School of African and Asian Studies.

8. Diemer, G. and van der Laan (1983) - Using Indigenous Skills and Institutions in Small-Scale Irrigation: an Example from Senegal. Irrigation Management Network Paper 8b. ODI, London.

9. Belloncle, G. (1985) - Paticipation paysanne et aménagements hydro-agricoles. Editions Karthala, Paris.

10. Tiffen, M. (1985) - Land Tenure Issues in Irrigation Planning, Design and Management in Sub-Saharan Africa. Working Paper No 16, ODI, London.

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# ECONOMICS OF IRRIGATION DEVELOPMENT

SUMMARY

**SUMMARY**

In considering the economics of irrigation development, an analysis has been based on eleven World Bank projects for which relatively detailed actual data are available. These projects were implemented in the following countries: Cameroon, Egypt, Madagascar, Mali, Morocco, Senegal, Sudan and Tunisia, in the period since 1970.

The cost structure of these projects indicates that major storage and flood control works which occurred in two projects accounted for 25 and 30% of total costs, illustrating the impact of such works on total cost. The cost of conveyance and distribution was low in the case of rehabilitation and flood control projects but rose significantly when more sophisticated systems were used, accounting for up to half the total cost. The extremely wide range of costs, even within the limited information available, shows the diverse characteristics of African projects of various types.

While data on operation and maintenance costs are less readily available, estimates for Francophone West Africa show a range from \$5/ha to \$17/ha for traditional flood recession, cultivation and semicontrolled flooding. For village-level schemes including pumping, O & M costs are from \$90 to \$140/ha, and for localized pressure supply and motorized groundwater irrigation, figures of \$300 to \$770/ha are quoted.

Factors contributing to high costs of irrigation in Africa are:

(i) physical; remoteness of the site which imposes high transport costs, the need for storage or major flood protection works, dispersed distribution of irrigable soils, limited resources of shallow groundwater;

(ii) due to the state of development of the continent; low density of population, lack of local equipment manufacture, supply difficulties, shortage of trained manpower;

(iii) due to government or donor policies; as overvalued exchange rates, high import duties and taxes, tied external funds; and

(iv) due to insufficient knowledge or confidence of local conditions; overdesign and high safety aod cost contingency margios.

In some projects reviewed, high benefits in rice projects were due to high crop yields and very intensive land utilization.

At the natiooal level, cost/benefit ananlysis of the eleven projects at time of completion showed that most of them had an acceptable ecooomic rate of return, in spite of the wide range of costs and benefits. Deterioration in management conditions and in prices caused a decline in viability at a later date in some of these projects.

In addition to overall economic viability, financial viability at the level of the farmer, irrigation agency, credit institution and government must also be considered for effective development of irrigated agriculture.

The improved viability of irrigation projects requires the removal of a number of technical, economic and social conatraints which lead to high costs and low levels of benefits. Of particular importance are meaaures for ensuriog full farmers' participation in planning and utilization of irrigation projects.

Consideration of policy options for future irrigation for Africa should start with the alternative of intensification of rainfed production where natural conditions are favourable as in the central humid belt and parts of West Africa. Future options for irrigation include low-cost improvement of traditional schemes, cheap rehabilitation of existing projects in deterioration conditiona and new irrigation. For the latter, it ia necessary to adapt the planning, design and equipment of schemes more appropriately to the specific Africao physical and socio-economic conditions, giving special attention to community participation and low cost technology, except where sophisticated irrigation may be essential for high value commercial production.

## I. INTRODUCTION

Estimates of cost and benefit at feasibility level are readily available for a number of projects. However, during implementation, changes in design, areas covered and project components result in very significant changes in quantities used, in addition to cost overruns due to frequent under-estimation of price contingencies (inflation). In this paper, therefore, it is proposed to use, to the extent possible, actual construction costs from completed projects, of which the source most readily available to FAO is the World Bank.

The cost data used refer to 11 World Bank projects constructed since the early 1970s. They are as follows:

| | |
|---|---|
| Cameroon | SEMRY 1 |
| | SEMRY 11 |
| Egypt | Nile Delta Drainage I |
| Madagascar | Lake Alaotra |
| | Morondava |
| Mali | Mopti Rice 1 |
| Morocco | Doukkala I |
| Senegal | River Polders |
| Sudan | Rahad |
| Tunisia | Irrigation Rehabilitation: Medjerda Nebhana |

For other cost estimates, not based on actual construction, various World Bank appraisal reports and FAO Investment Centre preparation reports are available. One such source is a recent FAO working paper on "Irrigation Costs in Francophone Africa South of the Sahara" which provides estimates of present costs in particular for small-scale projects, rehabilitation and improvement of existing systems, which are usually less readily available.

On the benefit side, the returns quoted in World Bank reports use the import parity price of tradeable commodities in the case of food production in substitution for imports, and export parity prices for production for export. The considerable changes in international prices of food commodities since project completion may lead to significantly different assessments today of the economics of the projects which were evaluated at project completion. The World Bank Commodity Price Tables are used for both export and import parity prices[1].

In spite of every effort to make inter-project comparison consistent, the specific characteristics of each project (due to the technical aspects of its topography, soils and water, economic and social characteristics of the populations concerned, supply of inputs and market prospects due to location) will be reflected in the costs and returns, and therefore in the economic viability of the project. It is hoped, however, that the range of irrigation and water control projects reviewed will indicate the various aspects which affect the viability of an irrigation project.

## II. COST ASPECTS OF IRRIGATION PROJECTS

Table 2 shows summary breakdown of actual costs for the 11 World Bank projects reviewed. More detailed breakdowns are sometimes available for some of the major components and will be drawn upon for the analysis. In Table 3, estimates of construction costs for irrigation systems in Francophone Africa are also given.

### II.1 Irrigation and Drainage Works

Investment Costs (actual costs of completed works)

There are few recent cases of projects in Africa with a major component for structures for water storage. The justification for major reservoirs usually arises from the need for power and/or urban and industrial uses, with agriculture benefitting from the surplus water resources mobilized.

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1) Half-yearly Revisions of Commodity Price Forecasts, December 1984.

Table 1

**Estimated Cost per Hectare of Selected World Bank Irrigation Projects;**
**Asia and Africa (feasibility level) 1/**

| | | Year of preparation | Irrigated area | | | Capital investment cost | | |
|---|---|---|---|---|---|---|---|---|
| | | | Command area develop. 2/ | Rehabilitation | New irrig. | Irrig. works | Agric. develop. | Total |
| | | | ha | | | $/ha | | |
| BANGLADESH | Low lift pumps | 1978 | - | 120,000 | 40,000 | 200 | - | 200 |
| INDIA | Rajasthan canal stage I | 1979 | 290,000 | - | - | 400 | 50 | 450 |
| BANGLADESH | Bhola irrigation | 1982 | - | 8,000 | 30,000 | 500 | 200 | 700 |
| INDIA | Uttar Pradesh public tubewells | 1979 | - | 60,000 | - | 500 | - | 500 |
| SUDAN | White Nile pump rehabilitation | 1979 | - | 72,000 | - | 600 | 400 | 1,000 |
| BANGLADESH | Deep tubewells | 1981 | - | 88,000 | - | 1,000 | - | 1,000 |
| SRI LANKA | Village tank rehabilitation | 1980 | - | 42,000 | - | 1,150 | - | 1,150 |
| ETHIOPIA | Small scale irrigation | 1983 | - | 1,600 | 2,700 | 1,700 | 100 | 1,800 |
| TUNISIA | Central Tunisia irrigation | 1982 | - | 8,600 | 1,200 | 2,500 | 900 | 3,400 |
| BURMA | Tank irrigation | 1981 | - | - | 2,400 | 3,300 | - | 3,300 |
| MOROCCO | Beni Amir rehabilitation | 1983 | 7,500 | 10,400 | - | 3,600 | 500 | 4,100 |
| TUNISIA | Shallow wells | 1984 | - | 900 | 1,900 | 3,300 | 300 | 3,600 |
| MOZAMBIQUE | Citrus development | 1980 | 1,200 | - | - | 5,100 | 4,800 | 9,900 |
| SENEGAL | Saldé-Wala irrigation | 1982 | 570 | 100 | - | 6,100 | 1,200 | 7,300 |
| YEMEN PDR | Hadramaut II rehabilitation | 1982 | - | 3,800 | - | 9,600 | 1,600 | 11,200 |
| MAURITANIA | Gorgol irrigation | 1980 | - | - | 3,600 | 13,300 | 1,600 | 14,900 |
| CYPRUS | Khrysokhou irrigation | 1982 | - | - | 2,000 | 17,400 | 2,600 | 20,000 |

1/ Costs do not include technical or price contingencies.

2/ Command Area Development are projects where major infrastructure already exists and the project is in fact an additional slice of an existing irrigation scheme.

Source: Investment costs in Irrigation Projects; Review of Irrigation Projects prepared by FAO Investment Centre, 1984 (internal working paper)

Table 2

**Costs of Eleven World Bank Irrigation Projects**

(actual costs in US$ million)

| | CAMEROON | | EGYPT | MADAGASCAR | | MALI | MOROCCO | SENEGAL | SUDAN | TUNISIA | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SEMRY I | SEMRY II | Drainage I | Lake Alaotra | Morondava | Mopti Rice | Doukkala I | River Polders | Rahad | Medjerda | Nebhana |
| A. Irrigation works | 3.35 | 22.18 | 141.37 | 5.15 | 28.9 | 5.01 | 49.90 | 8.66 | 164.6 | 6.66 | 1.05 |
| (of which major works - dam/dykes) | | (16.80) | | | (18.6) | | | | | | |
| - drainage) | | | (141.37) | | | | | | | | |
| B. Other infrastructure | | | | | | | 8.83 | | 48.0 | | |
| - roads | | | | | | | (6.26) | | (36.2) | | |
| - power network | | | | | | | (2.37) | | (11.8) | | |
| C. Buildings | 0.17 | 8.31 | 2.94 | - | - | 1.10 | 0.48 | 0.23 | 51.1 | 2.35 | - |
| E. Equipment | 1.24 | 13.33 | 35.16 | 0.48 | 0.4 | 1.46 | 15.35 | 1.42 | 45.2 | 2.38 | 0.76 |
| (of which irrigation/drainage) | (0.74) | | (30.34) | | | | (14.83) | | | | |
| farm equipment) | (0.28) | | (4.78) | | | (0.93) | | | | | |
| vehicles) | (0.22) | | | | | (0.24) | | (0.42) | | | |
| F. On-farm development | 1.33 | - | - | 1.33 | 5.1 | 0.71 | 0.19 | - | - | 5.98 | 0.42 |
| G. Processing storage facilities and other services | 0.47 | - | - | - | - | - | - | - | 39.4 | - | - |
| H. Research, extension and training | 0.42 | 0.67 | - | 1.09 | 2.8 | 0.17 | - | 0.23 | 1.6 | - | - |
| I. Technical assistance, consultants and studies | 2.08 | 13.42 | 0.58 | 0.69 | 2.9 | 2.12 | 0.71 | 0.63 | 13.7 | 0.80 | 1.65 |
| (of which - engineering) | | (6.44) | | | | | (0.31) | | | | |
| - consultants) | | | | | | (1.42) | | | | | |
| J. Project management and local expertise | - | 5.38 | 8.66 | - | 8.4 | 2.56 | 3.33 | 0.18 | 9.4 | - | 0.41 |
| K. Credit/stocks for inputs | - | 2.80 | - | - | - | - | 2.76 | - | - | - | - |
| L. Commercial activities | - | - | - | - | 8.1 | - | - | - | - | - | - |
| M. Settlement, population transfer, crop compensation, land consolidation | - | 1.87 | 10.17 | - | - | - | 1.08 | - | 16.4 | - | - |
| N. Social services | - | 0.84 | - | - | - | - | 0.17 | - | 6.2 | - | - |
| TOTAL | 9.28 | 68.44 | 198.88 | 8.94 | 56.6 | 13.14 | 85.01 | 12.35 | 393.6 | 18.18 | 4.29 |
| Cost per hectare ($) | 2,277 | 9,778 | 500 | 894 | 14,835 | 503 | 5,374 | 4,172 | 3,138 | 909 | 858 |
| Cost per family ($) | 3,234 | 8,123 | 764 | 3,193 | 11,928 | 1,682 | 5,443 | 7,485 | 2,826 | 10,100 | 2,145 |
| Year of project completion | 1977 | 1982 | 1880 | 1976 | 1883 | 1978 | 1981 | 1977 | 1883 | 1982 | 1982 |

Source: World Bank Completion Reports

Table 3

Estimated Construction Costs for Irrigation Systems in Francophone West Africa (1985)

| | Earthworks | Concrete structures | Pumps | Total |
|---|---|---|---|---|
| | US$/ha | | | |
| Controlled flooding, depth 1.3 m | 800 | 200 | - | 1,000 |
| Controlled flooding, depth 40 cm | 1,350 | 350 | - | 1,700 |
| Controlled flooding, depth 15 cm | 3,000 | 800 | - | 3,800 |
| Receding flood (River Niger) | 300-800 | 80-200 | - | 400-1,000 |
| Swampland development, simple | - | - | - | 200 |
| Swampland development, imrpoved | - | - | - | 800 |
| Surface irrigation, full control (excluding costs of storage or diversion dams and main canals): | | | | |
| - village schemes, river terraces | 1,000 | 700 | 1,500 | 3,200 a/ |
| - village schemes, lowlands | 2,600 | 1,800 | 1,000 | 5,400 b/ |
| - large schemes, river terraces | 2,400 | 800 | 1,200 | 4,400 c/ |
| - large schemes, lowlands | 4,600 | 1,200 | 1,000 | 6,800 d/ |

Source: "Irrigation Costs in Francophone Africa South of the Sahara", FAO working paper.

a/ Plus labour by beneficiaries.
b/ Plus labour by beneficiaries, but excluding levelling ($ 400/ha).
c/ Levelling at $ 400/ha (favourable site) would need to be added.
d/ Levelling at $ 1,600/ha (complete control) would need to be added.

Storage dams are of relevance to North Africa, and the sub-arid Sahelian and Southern Africa belt. In the less arid parts of Africa, irrigation requirements will be met by diversion dams although storage might still be considered primarily for hydro-electricity and flood control purposes. In North Africa, recent and current irrigation efforts concern utilization of water from existing storage dams and rehabilitation of existing systems. Thus, the Doukkala I project in Morocco was planned to utilize water resources from an existing "low service" main canal diverting water from the Im-Fout reservoir on the Oum-er-R'Bia river. Both the Tunisian projects were for rehabilitation and improvement of existing irrigation systems with already available water supply. The Rahad project in Sudan was also planned to utilize water from the already constructed Roseires dam on the Blue Nile. There do not seem to be any current proposals for construction of major storage structures in North Africa. In view of the fact that more than 70 percent of the irrigation potential is already utilized, the increased costs of construction and present financial stringency, it is not likely that further projects requiring major reservoirs will be considered in the near future.

In the better watered part of Africa, the SEMRY II project included the construction of two dykes for water control totalling 48 km. In an effort to reduce the cost of the dykes it was decided to modify the original designs, reducing protection against wave motion. The resulting leakages and dyke erosion problems had to be remedied at considerable expense. Of the total cost of the project, the dykes, at $16.8 million, accounted for equipment for dyke repairs and associated reinforcement works, bringing the cost to nearly 29 percent of total, or more than $2400/ha in 1982. In the Morondova project, the Darbara Diversion Dam cost $18.6 million and accounted for about one-third of the cost, or more than $4800/ha in 1983. Both of these projects proved to be quite expensive in most of their components as shown in Table 2.

Cost comparisons must take account of whether the project concerns improvement/-rehabilitation or new construction. For the Tunisian projects, costs amounted to some $ 300/ha for the Medjerda and $ 200/ha for the Nebhana. These were rehabilitation projects with specific inputs for repair of some key components for schemes originally constructed in 1960 for the Medjerda and in 1970 for the Nebhana. In the case of Mopti Rice in Mali, canals, embankments and regulators accounted for $ 5.0 million out of a total cost of $ 13.4 million, or some $ 200/ha in 1978. On-farm works amounted to an additional negligible amount of $ 30/ha. It should be noted that the Mali project did not provide for full water control.

Still referring to the less expensive projects, Cameroon SEMRY I provided for pumping water with surface distribution under full control. Excluding the cost of pumps, the distribution system amounted to $ 3.55 million out of a total cost of $ 9.28 million, or 38 percent of total, i.e. some $ 900/ha in 1977. On-farm works cost an additional $ 300/-ha. The Lake Alaotra project in Madagascar provided for rehabilitation of main canals and main drainage outfall, irrigation and drainage networks on 4000 ha and construction of new irrigation, drainage and road networks over 6000 ha of newly reclaimed land. These accounted for $ 5.15 million out of the total of $ 8.94 million, or more than half the costs, amounting to some $ 550/ha in 1976. Land development on farm added another $ 150/ha.

Egypt Nile Drainage is a special case where for a project area of 400 000 ha project components concerned remodelling of open drains ($ 190/ha), pumping stations ($40/ha) and tile drainage ($ 200/ha), a cost in total drainage works of $ 430/ha. It is not possible to separate distribution system costs and on-farm development costs in the Rahad project, which amounted to $ 164.6 million out of a total of $ 395.6 million, or a cost of some $ 1300/ha.

The Morocco Doukkala project included main surface distribution works, an underground pipe distribution system, drainage and system roads. Their costs, including on-farm works, accounted for $ 48.6 million out of a total of $ 85.0 million, amounting to $ 3150/ha (1981 prices). The Senegal River Polers project provided for pumping from the river and surface distribution with full water control. The costs of water conveyance and distribution, including on-farm works but excluding the pumps, amounted to $ 9.66 million out of a total of $ 12.35 million or $ 3300/ha in 1978. In the Morondava case, conveyance and

distribution, including drainage and system roads amounted to \$ 10.3 million, or some \$ 2700/ha in 1983. On-farm irrigation works on part of the area amounted to an additional \$ 2000/ha covered.

Investment Costs (estimates)

The above cost figures could be compared to those in Table 3 which are estimates and not actual costs. Structures for controlled flooding are estimated to increase from \$ 1000/ha to \$ 3800/ha as the control of water becomes stricter. These compare with costs at Mopti with partial control of \$ 230/ha in 1980 and at SEMRY I with full control of \$ 1000/ha in 1977. With the inclusion of two expensive dykes that needed repairs, costs are nearer to \$ 3200/ha for SEMRY II in 1982.

The estimated construction costs of surface irrigation schemes in Francophone West Africa exclude cost of water mobilization and land levelling. The range extends from \$ 3200/ha to \$ 6800/ha (1985 estimates) which should be compared to \$ 3600/ha for Senegal (1978 costs) and \$ 3150/ha for Morocco Doukkala (1981 costs).

### II.2 Other Economic Infrastructure

Only in two projects are there considerable costs for other economic infrastructure, i.e. roads and power network. In Morocco Doukkala, roads and telecommunications account for \$ 8.8 million or 10 percent of total costs, while in the Sudan Rahad roads and power network amounted to \$ 48.0 million or 12 percent of total costs. Where such infrastructure is not essential for the irrigation project's success, it may still be included at government request for technical, economic or political reasons of expediency. In the case of Doukkala, the costs of the roads were not considered essential for the project's success and were not included in the cost-benefit analysis. In the Rahad case, although the information is not very clear, it would appear that because of the lack of infrastructure in the project area and the necessity to cater for project and farmers' inputs and for the output, some infrastructural costs were included in the economic analysis.

### II.3 Social Infrastructure

Social services were included in three of the cases reviewed: in a negligible amount for Cameroon SEMRY II for a health programme; in Morocco Doukkala for pavement for village streets, and for a more significant amount in Sudan Rahad for public health and water supply. In the Doukkala project, the Government also implemented a health control programme not funded under the project.

### II.4 Broad Cost Comparison of Surface Gravity and Groundwater Irrigation

In the past, economic comparisons between groundwater and surface gravity projects were in favour of groundwater, at least around the Mediterranean, owing to:

- the elimination of main storage structures needed for surface gravity irrigation;

- the need for a more extensive distribution system for surface gravity than for groundwater irrigation;

- the low cost of energy for pumping.

An additional advantage was the development of groundwater by private initiative which did not involve allocation of resources by government.

The major drawbacks were the risks of increasing both costs and risk of failure because of the lowering of the water table, exhaustion of the water resource or saline intrusion near the coastline, etc. Government intervention to control anarchic groundwater development by private enterprise, while recognized to be necessary, proved in practice to be very difficult to implement. However, groundwater and surface gravity developments were rarely strictly comparable owing to the usually small acreages involved with a groundwater development project as against a surface project. Comparisons made for project feasibility

needs in the Mediterranean region in 1970 indicated a total investment for groundwater of \$ 1500-2000/ha as against \$ 3500-4000/ha for surface schemes (including main storage), and annual operating costs of \$ 60/ha for groundwater as against less than \$ 10/ha for surface irrigation. It is obvious that the requirement of even a minimal return on the difference in investment of \$ 2000/ha would, under these conditions, far outweighs the higher operating costs due to pumping.

The present situation is far from clear for comparison purposes. Groundwater is being lifted from deeper aquifers with a need for larger distribution systems; energy costs are much higher and the risk of exhaustion which applied initially to the shallower aquifers now concerns even the deeper ones. A further complicating factor for comparison purposes is the present use of large-scale pumping (with the consequent energy costs) to lift water from rivers, lakes or large storages for surface irrigation as in the Sudan, Senegal and Morocco.

A comparison of per hectare investment costs in five cases of groundwater and four cases of surface irrigation, as estimated in feasibility studies prepared by FAO is given in Table 4[1]. Although the countries concerned do not all belong to Africa, the figures illustrate the wide range of costs prevailing for both groundwater and surface irrigation projects, i.e. from \$ 700/ha for well and pump set in Bangladesh with no distribution or on-farm development costs, to \$ 2000/ha and \$ 2800/ha for tubewell and pumps for Tunisia and Egypt for very deep tubewells. To these should be added another \$ 5000 and \$ 4500/ha for distribution and on-farm development for Tunisia and Egypt respectively. In the same table, the low cost of run-of-the-river diversion at \$ 80/ha and \$ 250/ha has to be compared to \$ 1600/ha and \$ 2500/ha for storage dams. Distribution systems and on-farm development for the four surface water projects are of the same order of magnitude: \$ 880/ha to \$ 1030/ha. Under these circumstances, the technical characteristic of mobilizing the water resource determine to a large extent the level of investment costs whether for groundwater or surface irrigation.

### II.5 Schedules of Construction and their Impact on Costs

Any cost-benefit analysis must take account of the occurrence in time of expenditures and benefits. Delay in completion of construction works, in cases where it is not possible to use the completed portions of the works for irrigation, will appreciably raise the costs of the project. Usual analysis of this type refers to construction of major works upstream which lie unutilized for years before irrigation development downstream and agricultural production take place. It is usual in irrigation projects where major storage or diversion works are required to have a construction schedule over 5 to 7 or 8 years, with production starting on a very small scale in the 3rd to the 5th year, as soon as water deliveries can take place.

There are two economic aspects to be considered: the immobilization of investments in assets that do not yet yield returns, especially if these include full infrastructural costs, and the risk of deterioration of the asset itself during the time it is immobilized. In the region, major works have required repairs and rehabilitation before they were even utilized for production. Outside the region, many storage works built in the past have lost a considerable proportion of their storage capacity by silting before the water was utilized for production, thus reducing the productive area. This last point deserves special attention. The initial estimates of suitable soils, water availability and reliability, area of command and sustainability of soil suitability under irrigation have often proved over-optimistic. So also has the predicted cropping intensity. A combination of such divergencies from the planned scheme performance has a profound effect on the unit development costs and on the level of returns per hectare.

### II.6 Special Cases of Multipurpose Schemes and Sunk Costs

As mentioned earlier, the major impetus for large storage dams has arisen more often in the power or urban or industrial sectors rather than from agricultural needs. A multipurpose project has the advantage of accumulating benefits from more than one sector with the possibility of allocating investment costs also to more than one sector. There are various methods of cost-benefit analysis for multipurpose projects. The aspect of major interest, however, is in the different basis of cost analysis used, for example, to

1) "Investment Costs in Irrigation Projects, Review of Irrigation Projects prepared by the FAO Investment Centre", 1984, an internal working paper.

Table 4

Unit Costs per Hectare of Storage Gravity
and Groundwater Pumping Systems (feasibility level)

A. GROUNDWATER

| | Shallow wells TUNISIA | Deep tubewells 100 m-deep BANGLADESH | 100 m-deep TURKEY | 330 m-deep EGYPT | 400 m-deep TUNISIA |
|---|---|---|---|---|---|
| | $/ha | | | | |
| Well | 1,900 a/ | 500 | 390 | 2,100 b/ | 1,600 |
| Pump set | 700 | 220 | 1,050 c/ | 700 | 400 |
| Water distribution system | 400 | - | 640 | 4,500 | 5,000 |
| On-farm development | - | - | 320 | | |
| Total | 3,000 | 720 | 2,400 | 7,300 | 7,000 |

a/ masonry well 17 m-deep, 4.5 m diameter
b/ stainless steel screen
c/ including power line

B. SURFACE WATER

| | Run-of-the-river Turkey | Run-of-the-river Ethiopia | Storage dam Turkey | Storage dam Ethiopia |
|---|---|---|---|---|
| | $/ha | | | |
| Diversion weir/storage dam | 80 | 250 | 2,500 a/ | 1,600 a/ |
| Main canal | 560 | 510 | 640 | 150 |
| Distribution system | | 520 | | 750 |
| On-farm development | 320 | - | 320 | - |
| Total | 960 | 1,280 | 3,880 | 2,500 |

a/ excluding land acquisition

Source: Investment Costs in Irrigation Projects; Review of Irrigation Projects prepared by the FAO Investment Centre, 1984 (internal working paper)

Table 5

Irrigation Schemes in Francophone West Africa:
Estimated Annual Operation & Maintenance Costs a/

| | Annual fixed costs | | Pumping costs | | |
|---|---|---|---|---|---|
| | % of investment | Total $/ha/yr | Manometric height (m) b/ | US¢/m3 | Remarks |
| **Controlled Flooding** | | | | | |
| - standard system | 1 | 10 | - | - | Costs partially borne by farmers |
| - improved system | 1.5 | 6 | - | - | " " " " " |
| - weir | 1 | 5 | - | - | " " " " " |
| - semi-controlled system | 1 | 17 | - | - | " " " " " |
| - secured system | 1 | 38 | - | - | " " " " " |
| - supplementary pumping: | | | | | |
| (a) Indian pump | - | - | 5 | 1.6 | |
| (b) Lister pump | - | - | 5 | 2.0 | |
| **Swamp or Lowland Schemes** | | | | | |
| - basic | 1 | 2 | - | - | Plus farmer's contribution to maintenance |
| - improved | 1 | 8 | - | - | |
| **Flood Recession Irrigation** | | | | | |
| - Mauritanian dams | 1 | 16 | - | - | Probably over-estimated |
| - Niger flood recession | | | | | |
| (a) Lake Region | 1 | 5 | - | - | |
| (b) Central Niger | 1 | 9 | - | - | |
| - Dogon dams | 1 | 80 | - | - | |
| **Groundwater Irrigation** | | | | | |
| - animal pumping | - | 270 | 25 | 14 | Probably over-estimated |
| - motorized pumping | - | 270 | 35 | 10 | " " " |
| **Pressure Irrigation** | | | | | |
| - small-scale | - | - | 40 | 8.4 | |
| - large-scale | - | - | 70 | 7.4 | |
| - localised irrigation | - | 180 | - | 3.0 | |
| **Surface Irrigation** | | | | | |
| - individual developments | - | - | 8 | 2.4 | Costs partially borne by farmers |
| - village-level schemes: | | | | | |
| (a) river terraces | - | 19 | 10 | 1.5 | " " " " " |
| (b) lowlands | - | 84 | 6 | 1.1 | " " " " " |
| - medium-sized schemes | - | (see small-scale) | | | |
| - large schemes | | | | | Includes limited labour contribution by farmers |
| (a) river terraces | 1 | 53 | 9 | 0.8 | |
| (b) lowlands | 1 | 63 | 4 | 0.4 | |

a/ For lack of specific information, the figures below are very approximate estimations.

b/ 5 to 10 m should be deducted from manometric height to obtain the water level in the borehole.

Source: "Irrigation Costs in Francophone Africa South of the Sahara", FAO working paper.

provide water for power or for urban needs as compared to agriculture. The approach in the first case takes the need for granted (i.e. x millions of kWh or y millions of $m^3$) and will search for the most cost-effective method of providing for the need. The actual revenue derived will be a compromise between what users are willing to pay, and political considerations. The inclusion of water storage for agriculture, has to be justified by proving that the use of the water will produce sufficient economic benefits to justify any increased investment costs. Not only should the development proposed be cost-effective but it should also be economically viable.

The allocation to irrigation of part of the cost of a storage dam after the dam has been built has no impact on usual economic analysis since the dam will be considered as a "sunk cost", and calculations are based on incremental costs and incremental returns. In the cases of Rahad and Doukkala, the main storage work existed and was not included in the costs in the economic analysis.

### II.7 Operation and Maintenance Costs

The World Bank projects reviewed here usually provide total overhead and management costs for the government agencies concerned, without the possibility of isolating the cost of operation and maintenance of the irrigation system. Nevertheless, data are available for Morocco Doukkala where, in 1981, with a sophisticated sprinkler system, cost of maintenance and replacement amounted to $ 219/ha while energy costs added another $ 120/ha.

Another source of information is a World Bank review carried out in 1981 where water management in 26 projects (5 of which in Africa) was covered. The review showed annual average operation and maintenance cost of $ 145/ha for pump systems, $ 31/ha for gravity systems with full water control and $ 15/ha with partial control.

A further source of data (estimates not actual costs) is the paper on "Irrigation Costs in Francophone Africa South of the Sahara". It gives fixed maintenance costs and variable (pumping) costs. As shown in Table 5, costs for traditional irrigation would range from $ 5/ha for Niger flood recession in the Lake Region to $ 17/ha for semi-controlled flooding, to $ 80/ha for the Dogon Dam in Mali where maintenance and repair needs are high. For village-level schemes including pumping (for a requirement of 5000 $m^3$ at the pump), costs range from $ 94/ha for river terraces to $ 139/ha for lowlands, to $ 330/ha for localized pressure irrigation systems to the extreme of $ 770/ha for motorized groundwater irrigation. Only high-value crops would make an economic proposition of the use of such costly water, unless all other scheme costs are low and reliability, production levels and markets are assured.

## III. FACTORS CONTRIBUTING TO HIGH-COST IRRIGATION

Table 2 gives total costs and cost per hectare for the 11 World Bank projects reviewed. It should be kept in mind that these costs are actual expenditure incurred during the construction period, e.g. costs incurred in year 1, have not been updated before totalling. They contain therefore a strong and variable element of under-estimation, especially for projects implemented in the middle and later 1970s when inflation rates were very high. Drawing on Table 2, the 11 World Bank projects reviewed have been listed below in the order of rising costs without updating to today's costs. The orders of magnitude are not critically affected by updating.

Listing of projects in the order of rising costs

| | Completion Date | Cost ($/ha) |
|---|---|---|
| (a) Water Control Projects | | |
| Egypt Drainage | 1980 | 500 |
| Mali Mopti Rice | 1980 | 500 |
| Tunisia Nebhana | 1982 | 860 |
| Tunisia Medjerda | 1982 | 910 |

(b) Irrigation & Drainage Projects

| | | |
|---|---|---|
| Madagascar Lake Alaotra | 1976 | 900 |
| Cameroon SEMRY 1 | 1976 | 2 240 |
| Sudan Rahad | 1983 | 3 140 |
| Senegal River Polders | 1978 | 4 170 |
| Morocco Doukkala I | 1981 | 5 370 |
| Cameroon SEMRY 11 | 1982 | 9 780 |
| Madagascar Morondava | 1981 | 14 740 |

The list contains categories of projects which are scarcely comparable and include different ranges of components. Egypt Drainage and the Tunisian projects, with a low cost per hectare, can be considered as the category of rehabilitation where a limited input to meet a critical need cao salvage an existing syetem. Another category includes flood control projects with partial water control at Mopti ($ 500/ha) and full control in Lake Alaotra ($ 900/ha). The fuller control is compensated by higher cropping intensity. With SEMRY 1 ($ 2240/ha) costs rise with pumping and surface dietribution, rehabilitatioo of a dyke as well as construction of a new 32 km open maio draio, rehabilitation of irrigation and drainage network on 1300 ha and construction of new networks with on-farm development on 3000 ha.

Sudan Rahad ($ 3140/ha) was a completely new system to be constructed, except that it benefitted from storage of the Roseires dam, but cotton, groundnuts and vegetables (high value crops) would make it economically viable. The Doukkala project included e complete sophiaticated system of canals, pumping stations, water towers, underground pipee, hydrants and mobile sprinklers. Aleo here the poesibility of growing industrial crops (cotton and sugarbeet) with vegetables gives high returns which compeosate for the cost ($ 5370/ha).

With Senegal River Poldere the unit cost ($ 4170/ha), reflects the cost of a dyke for flood protection (which required repairs), full control and distribution. Such a cost is not likely to be compensated by growing one crop of a staple food even with high yields. The same would apply to SEMRY 1I ($ 9780/ha) which included a storsge pond, gravity eyetem with major works (48 km dykes), constructioo of a main drain, and irrigstion and drainage network oo 7000 ha, but through double cropping and if the very high yields can be maiotained, such a level of costs becomes economic. The World Bank report states that 4.5 t/ha of rice in the rainy season and 5.5 t/ha in the dry season were being produced at project completion. With the Morondava project, the coets ere very high, not only because of expensive works but also because of delays due to political changes. Such a coet precludee economic viebility except poeeibly for double cropping of high-value vegetables, which is unfortunately not the case.

With reference to estimates of present costs (Table 3) high costs are reached for controlled flooding (depth of 15 cm) and surface irrigatioo with full control, particularly in the lowlands for both small and large schemes. The costs rise in line with the more stringent control requirements of the eystem. When it ie considered that these costs do oot include water mobilization, laod levelliog, maoagement, supervisioo or essential support items such as offices, workshops and housing for the project staff, the fioal cost is likely to be much higher. To this msy also be added the costs of settlements, village iofrastructure and social aervicea and any road access, dependent on oatiooal circumstances and policies.

Some of the main factors contributing to high cost irrigation are intrinsic to the natural conditions of the couotry and to its state of development. Others derive from the policies of African governments or external lending agencies as well as from the practice of consulting and contracting firms. Among causes of high cost due to physical conditioos are the following:

- High transport costs resulting from long distances between the site, population aod delivery or demand centres, and poor roads. The problem is moet severe in land-locked countries where the cost of construction materials and equipment is raised by 50 to 100 percent owing to distance aod poor roads ae can be seen from the following figures:

Some cost factors in 4 countries

| Item | Burkina Faso | Cameroon | Malawi | India |
|---|---|---|---|---|
| | US$/unit | | | |
| Cement (t) | 125 | 105 | 115 | 80 |
| Steel (t) | 795 | 800 | 1000 | 560 |
| Diesel fuel (l) | 0.60 | 0.32 | 0.60 | 0.32 |
| Unskilled labour (man-day) | 1.50 | 2.30 | 0.43 | 1.35 |
| Civil Engineer (year) (5-10 years' experience) | 4900 | 7100 | 4600 | 2700 |

- Reservoirs and dams are essential to stabilize the erratic flows of many African rivers. Because of the central basement complex, suitable dam locations will be found along the escarpment, requiring considerable length of canals to bring the water to the flat lands to be irrigated. Alternatively, unusually long, low and expensive reservoirs will have to be built on the flatter topography with a high level of evaporation. In North Africa, dam locations are easier to find but the quantities of water mobilized are low in relation to cost because of the lower rainfall. Even the river coming from outside North Africa, i.e. the Nile, with its extensive well-watered watershed, was affeced by the recent drought. But for the Aswan High Dam, the effects on the Egyptian economy would have been disastrous.

- Major flood protection dykes are necessary for most rice schemes. The lower costs encountered for irrigation in the flood plains in Asia are also due to the fact that such dykes already exist, having been built a long time ago.

- While overall there may be no dearth of irrigable soils, their distribution is generally patchy, calling for complex water distribution and drainage networks with considerable levelling.

- There are few abundant sources of shallow groundwater suitable for local irrigation or conjunctive use, comparable to those of India and Pakistan.

- Because of the severe climate with possibility of very intense rainfall and droughts, high irrigation duties and wide safety margins are applied in project design.

Factors due to the state of development of the country include:

- The low population density: areas selected for construction of irrigation schemes may require investment in land clearing and access tracks as well as transfer of population with related social infrastructure and housing costs.

- The lack of local manufacture of equipment and spares and supply difficulties which lead to the necessity of carrying heavy stocks or result in delays in construction, as well as scarcity of good servicing and repair facilities.

- The shortage of local managers and trained technicians resulting in inefficient operations or need for costly and continuing expatriate supervision.

High costs attributable to governments and investors' policies include:

- Over-valued exchange rates of most African currencies which inflate costs in dollar terms.

- Relatively high import duties and taxes e.g. on labour or fuel which raise certain costs.

- The use of tied external funds to build irrigation networks often involving additional supervision and administrative costs and the procurement of non-standard equipment requiring special maintenance and service arrangements.

- The relative inflexibility in project construction due to agreements entered into by governments and lending agencies. Lower costs could be achieved if changes in approach or design could take place on the basis of experience during the early years of construction. Also simplified designs could be adopted on the understanding that reinforcement or further protection could be added later on those sections of the works requiring such reinforcement. This assumes availability of unallocated funding for such purposes.

Most studies and construction works are carried out by foreign firms. High costs can be attributed to the practice of these firms through:

- Over-design to preserve the reputation of the consulting firm, with excessive safety precautions leading to considerable extra costs in civil engineering works. Unfortunately, few national irrigation departments have the highly qualified personnel able to review the studies from these aspects.

- Insufficient knowledge of local conditions and experience to design structures in line with local materials availability and to use equipment in line with local capabilities. This results in unnecessary imports of more sophisticated materials, or of equipment with greater risk of breakdown.

- The tendency of contractors to add to their bids a sizeable element to cover the risks they perceive in operations in Africa.

## IV. BENEFIT ASPECTS

### IV.1 Crop Production

The direct benefit aspects derive from the incremental agricultural production due to irrigation. The primary need of the region is for increased production of staple foods, while high-cost of irrigation would need to be justified by high-value production. This is confirmed in reviewing, in the 11 World Bank projects, the range of crops adopted by the farmers, yields and production as shown in Table 6.

Both the Cameroon projects with only paddy as a crop show high yields due to the farmers' general acceptance of transplanting, and high levels of land utilization (163 and 180 percent, a wet season and a dry season crop). The Madagascar projects also have paddy as the only crop but with lower yields and no double cropping. In Lake Alaotra, farmers living at a distance from the fields did not double crop. In the Morondava, low yields were due also to poor design of canals and poor land levelling. The Mali project has also only paddy with still lower yields and no intensification due to limited adoption of improved cultivation techniques, wild rice infestation and only partial flood control. In the Senegal River Polders, a high-value crop, tomatoes, comes in with paddy but there is no intensification of land utilization[1]. For the remaining projects the range of crops is high-value and greatly diversified with industrial crops, sugarbeet in Doukkala, cotton and groundnuts in Rahad and cotton in Egypt, vegetables (Rahad, Doukkala, Medjera and Nebhana) and fruits (Medjerda and Nebhana). The cereals are maintained in the crop rotation mainly by reason of agronomic requirements. The degree of intensification of land use is generally high.

### IV.2. Markets and Prices

Provided the farmer is free to select the crops and the scheme's design allows alternative cropping, the range of crops will depend on markets and attractive prices. Experience in the Cameroon projects is highly instructive. The rice production of SEMRY I created no marketing problems despite great distances from centres of consumption and the resulting high transport costs, except in 1976 when low-priced imports forced the project authority to suspend milling and sales for several months. Problems occurred again in 1979 as a result of massive imports of Asian rice in spite of the system of "jumelage" introduced by the Government requiring traders to buy a certain amount of local rice to obtain import licences. SEMRY's stocks were disposed of eventually by trade with Nigeria. In 1982 and 1983, again marketing problems occurred with stocks building up from SEMRY's projects. By the end of 1983, the Government had introduced a subsidy of FCFA 25/kg of rice sold by

1) This is also due to unavailability of water for a second crop pending entry into operation of the Diama and Manantali dams.

Table 6

## Benefits

| | | Crops | Yields t/ha | Cropping intensity % | Incremental output t |
|---|---|---|---|---|---|
| CAMEROON | SEMRY I | Paddy (wet season) | 4.5 | 163 | 18,335 |
| | | " (dry season) | 4.5 | | 13,500 |
| " | SEMRY II | Paddy (wet season) | 4.5 | 180 | 53,000 |
| | | " (dry season) | 5.5 | | |
| MADAGASCAR | Lake Alaotra | Paddy (one crop) | 3.0 | 100 | 24,500 |
| " | Morondava | Paddy (one crop) | 2.6 | 90 | 16,000 |
| MALI | Mopti Rice | Paddy (one crop) | 0.9 | 100 | 29,100 |
| SENEGAL | River Polder | Paddy (one crop) | 4.5 | 100 | 3,544 |
| | | Tomatoes | 25.0 | | 6,975 |
| SUDAN | Rahad | Cotton | 2.3 | | 114,000 |
| | | Groundnuts | 1.8 | 83 | 43,300 |
| | | Sorghum | 2.8 | | 37,370 |
| | | Vegetables | 15.1 | | 43,365 |
| TUNISIA | Rehabilitation Medjerda | Fruit | | 100 | 19,200 |
| | | Vegetables | | | 34,500 |
| " | Rehabilitation Nebhana | Fruit | | 100 | 12,400 |
| MOROCCO | Doukkala | Wheat | 4.0 | | 6,768 |
| | | Maize | 4.5 | 146 | 7,840 |
| | | Sugarbeet | 60.0 | | 195,960 |
| | | Vegetables (summer) | 40.0 | | 130,646 |
| | | " (winter) | 30.0 | | 72,660 |
| | | Fodder crops | 60.0 | | 444,680 |

Source: World Bank Completion Reports

The above experience underlines the fact that in spite of the need of the region for staple food production, marketing problems arise as soon as a sizeable production is put on the market because of the risk of low-priced imports being dumped on the market at the same time. It also points out to the need for some protection even for a normally efficient producer (with high yields as in both SEMRY projects). Other projects did not encounter similar problems. The national rice production of Madagascar is so important that the incremental production from both projects did not affect the market. The rice projects coincided also with a high and rising international price for rice from 1976 to 1981, followed unfortunately by a considerable drop. Problems of low prices and marketing also affected the tomato crop in the Senegal project as soon as areas and output increased substantially.

Rahad has a highly diversified crop pattern with a traditional crop, cotton, for which compulsory marketing arrangements existed. The tenant had to grow certain crops as decided by the project authority on the regular plot. He was, however, free to grow the crops of his choice on his own free lot. Unattractive prices in the beginning discouraged intensification and high yields on the regular plot (controlled rotation) to the benefit of the free lot put under vegetables, but soon marketing problems arose for vegetables and better prices were paid on the traditional crops which encouraged higher yields on the regular plot.

The Doukkala project produced substantial increases in sugarbeet and vegetables. The first was supplied to the sugar factories and the vegetables were marketed in the neighbouring urban areas. Import savings arose mainly from import substitution of sugar. In line with market demand the development of summer and winter vegetables assured a high income to farmers and high returns to the project.

In the Tunisian projects, fruits and vegetables, i.e. high-value crops, covered about two-thirds of the area with a shift during the project to winter vegetables with better prices and stronger demand, and to "covered" vegetable production, all in response to market forces.

### IV.3 Intensification of Crop Production

The speed at which farmers utilize the irrigation water, alter the crop rotation in line with irrigation possibilities, intensify cropping with a wet and a dry season crop (winter and summer in North Africa) and increase yields will affect the benefits of a project and its economic viability. In areas where there is a tradition of irrigation and where support services are well developed as in the North African countries, the speed has been very high. Under some circumstances, in the Cameroon case for instance, intensification was rapid, with double cropping of rice and yields rose spectacularly. The experience was less favourable in Madagascar where no intensification took place. The possibility of intensification and higher yields in Mali (Mopti) was limited by the partial water control. In the Sudan, in spite of the fact that farmers were mainly settled nomads, yields did not compare too unfavourably with other irrigated areas.

### IV.4 Socio-economic Factors

Apart from North Africa and Sudan where irrigated agriculture has a long tradition, the African farmer still considers his traditional flood irrigation or flood recession cultivation as only part of his total farming system which includes his rainfed crops, livestock and any other activity. Priority is given to the rainfed area as soon as the rains arrive and the flooded plot is considered only as an extra insurance against crop failure. Under such circumstances, the low utilization of an irrigated plot may result for the farmer in the best advantage to be drawn from the total farming system, taking into account his other farming activities and labour availability. Maximizing returns on the irrigated plot alone is not necessarily his objective. For example, he may prefer to have his livestock graze the grass after the flood recedes, than to plant a crop if his rainfed area will supply him with his food needs.

During the recent drought, it was reported that African farmers, particularly in sub-arid regions, have paid greater attention to their irrigated plots, as was to be expected when no crop production was being obtained from the rainfed area. It will be

important to follow the future behaviour of the farmer under normal rain conditions. In any event for the farmer to devote more time and effort to the irrigated plot will require the assurance that irrigation will supply him with the food or cash needs he is expecting to derive from it. There develops a vicious circle whereby the farmer will not intensify irrigated production unless he is sure of the water and his other supplies, but the low level of intensification on irrigated land does not justify improving the system to obtain greater assurance of water supply, or to establish support services. Under such circumstances labour availability for improving production under irrigation is likely to remain a serious concern for Sub-Saharan Africa with little tradition of intensive irrigation.

### IV.5. Other Benefits

Decision on a development scheme may be based on the policy to promote a depressed or backward region. The rate of return analysis does not take into account the multiplier effect on local activities of increased demand for agricultural supplies, tools, transport and the increased incomes to be spent on consumer durables and consumption goods. The "Méthode des effets" does cover this aspect; unfortunately there is usually too little basic information to build meaningful input-output tables.

## V. ECONOMICS OF IRRIGATION AT NATIONAL LEVEL

### V.1 Cost-Benefit Analysis

The international lending agencies use the internal rate of return to evaluate the economic viability of the projects they are considering for financing. The method is well known and aims at finding the interest rate (the internal rate of return) for which discounted incremental costs and discounted incremental returns are equal. For a project to be viable, this should be at least equal to opportunity cost of capital for that type of project. Costs and returns are real economic values, i.e. adjusted for taxes, duties, subsidies (i.e. any transfer of resources) and price of factors such as foreign exchange and labour may be adjusted in the economic analysis to reflect a more realistic price, given the demand and supply conditions of that factor.

Francophone countries often use the "Méthode des effets" which aims at simulating a priori or evaluating a posteriori the impact of a project on the main economic flows such as intermediate consumption, the sharing-out of value added and the use made of the incremental income by the economic agents concerned. Input-output tables are used and the method enables the evaluator to follow through the project impact on other activities or sectors of the economy, in particular the foreign balance. Selection of projects is based on criteria already established by the National Plan, e.g. foreign exchange savings, redistribution of income, etc.

The World Bank projects reviewed have been evaluated by the method of the Economic Internal Rate of Return and the results at completion of project were estimated as follows:

Economic Return

| | | Economic Internal Rate of Return (%) | Cost $/ha |
|---|---|---|---|
| Cameroon | SEMRY I | 23 | 2 240 |
| " | SEMRY II | 20 | 9 780 |
| Egypt | Delta Drainage | 25* | 500 |
| Madagascar | Lake Alaotra | 22 | 900 |
| " | Morondava | extremely low | 14 740 |
| Mali | Mopti Rice | 17 | 500 |
| Morocco | Doukkala I | 20.5 | 5 370 |
| Senegal | River Polders | 8 | 4 170 |
| Sudan | Rahad | 19.5 | 3 140 |
| Tunisia | Rehabilitation Medjerda | 32 | 910 |
| " | Rehabilitation Nebhana | 33 | 860 |

Considering that a rate of return of 8 to 12 percent is usually the level acceptable at present for an irrigation project, the projects reviewed pass the test successfully except for the Morondava where the extremely high cost could not have been compensated except for very high value crops such as vegetables and very intensive land use, and for Senegal River Polders where the return is at the lower limit, not only because of the relatively high cost of the works but because of low benefits due to low intensification (no double cropping possible until the Diama and Manantali dams come into operation).

Further consideration shows that SEMRY II was viable only because of very high yields and two crops of paddy, and the question arises as to whether this performance (9.5 tons of paddy/ha/year) could be easily maintained or replicated under African conditions. The economic results above were obtained at project completion when projects were still benefitting from very intense support and supervision, and considerable pressure on the part of the donor to obtain from the governments concerned the resources in funds and manpower and the policy decisions required to make a success of the project. Unfortunately, World Bank reviews made a few years after completion of the projects have been faced in several cases with a decline in project economic performance probably due to the withdrawal of the heavy support during project implementation and to increasing financial and managerial difficulties of governments under harsher world economic conditions.

Although in the sample reviewed high cost projects presented as good a level of return as low cost projects, it is obvious that a much higher degree of risk is involved with high-cost projects because of the stricter requirements on yields and intensification of land use, which would be difficult to achieve by farmers in transition from a self-subsistence agriculture. There is therefore an obvious priority for lesser-risk projects such as those of rehabilitation or improvement of existing systems requiring a lesser degree of intensification, until such time as the Sub-Saharan farmer will have acquired the familiarity with and the tradition of intensive irrigation.

## V.2 Foreign Exchange Balance

It has been mentioned that a shadow price for a factor may be applied in the economic analysis if it is believed that the official price does not represent the real supply and demand conditions. In the case of Africa, it is often the case that national currencies are over-valued. This is probably true of West African countries, but the relative importance of foreign versus local costs should be examined to assess the possible impact of over-valuation on the economic results while the problem of where to set the exchange rate to be used for economic analysis remains. The calculations were made in the case of the Senegal project converting local costs at a shadow exchange rate of FCFA 270 to the US$ instead of FCFA 220, the official rate at the time of project implementation. This would raise the return from 8 to 9 percent. In the case of Egypt, the parallel market rate was used as representing more realistically the real value of the currency.

The effect of over-valuation of a currency is in fact much more relevant in its effect on the choice between local and foreign procurement (where such choice is possible) than in its effect on the rate of return. Local goods including labour become expensive and lead not only to alternative imports, but also to technical solutions which may be more capital-intensive because of the high cost of local labour.

Of great interest is also the impact of the project on the balance of payments of the country concerned. Where a country has acute balance of payments problems, a rate of return calculation may be carried out solely on the foreign exchange component of costs and returns. The costs would include also the foreign exchange component of operational and replacement costs for the irrigation system, and production costs of farmers. On the returns side would be the import savings through local production of food or increased export earnings. Such an analysis would bring out situations where, because of the dependance of a country on imports for most of its supplies, the import savings on food may be almost balanced by imports of replacement equipment, energy, fertilizers, farm machinery, etc.

## V.3 Labour Aspects

There are two economic aspects to the labour issue in Africa: first that it may be

expensive because of government minimum wage policy and/or taxes on wages which affect investment as well as operating costs, and secondly that it is not available for construction works or for agricultural operations to draw full advantage from irrigation projects. Most countries have a minimum wage policy which a government entity or a foreign contractor would find it difficult to ignore. The level of the minimum wage may not be realistic, taking into account the number of unemployed searching for work in the urban areas, but the relevant factor is the availability of labour for work at the project site or for its agricultural operations. Upon reviewing the project documents, it appears that availability of labour, in particular for intensifying crop production, has often been a problem. As a result, there are already numerous examples of mechanized irrigation in Africa, to reduce the dependence on labour. This trend can be expected to increase where continued demands for produce are ensured.

## VI. FINANCIAL ASPECTS

### VI.1 Sources of Financing

In addition to World Bank/IDA financing, in the Francophone countries, French assistance often shared in the external financing, while Arab sources shared in the external financing of projects in the Arab countries. For example, the FAC and CCCE participated in both SEMRY I and SEMRY II while the Kuwait Fund, the Arab Fund and the Saudi Fund for Development participated in the financing of the Rahad project.

Local financing came from the public sector, beneficiaries contributing their labour for works on the farm plots, if at all. However, in those cases where processing facilities have been included, national development banks have occasionally participated in loans and sometimes in equity.

### VI.2 Allocation of Costs and Cost Recovery

Whereas the economic viability of a project is based on economic costs and returns at the national level, the allocation of costs to the various particpants is a question of policy, provided the basic requirement of ensuring agricultural development is fulfilled, i.e. that the farmer is willing to utilize the irrigation water, to intensify land utilization and to devote sufficient resources to his crops to obtain the required yields.

The practice has been that for new large schemes the investment works are paid for by the State. In the past, these works stopped at the farmgate on the assumption that the farmera would build his own irrigation and drainage ditches and bund and level the land. For new modern schemes, experience in North Africa soon convinced governments to provide also the on-farm works, including levelling, to ensure adequate utilization of the irrigation water. The cost was to be recovered partly or wholly from the water charges. Where commercial farmers were concerned with well diversified farms and a high level of assets, the agricultural credit institutions were asked to give loans to farmers for on-farm development. Where industrial crops requiring processing, were grown, the cost of farm inputs and water were recovered from the farmer upon delivery of his output to the marketing authorities.

National considerations require that the maximum of cost recovery should be obtained from the farmers who are benefitting from the project and who have thus become priviledged in relation to the rest of the farming population. Maximum cost recovery would recycle resources allowing governments to extend development to other farmera or other sectors of the economy. However, in the extreme case, farmers may refuse to utilize the water if it is considered too expensive. Therefore the actual level of cost recovery must be acceptable to the farmer and should be based on a realistic farm budget to assess his capacity to pay. On large projects such as tha Rahad, the farmer is only a tenant and can be turned out if he is not performing satisfactorily. This provides some assurance that the large government investment will be properly utilized. In practice, however, the cost of water is usually set very low and does not represent a significant factor in relation to the total costs of a diversified intensive farm.

Whatever the level set for the water charge, it is usually intended to cover at least the cost of operation and maintenance of the system to allow it to continue under satisfactory conditions. Government subsidization should not extend to operation and maintenance costs unless such costs are covered through other economic transactions with the farmers. For example, paddy or seed cotton may be purchased from the farmers at a low price which allows the buying authority an additional margin to reimburse the entity operating the system for its operation and maintenance expenses. While such arrangements may be practical for cost collection purposes, they lack the clarity required to convince the farmer of the necessity of such payments. Another practical reason for cost recovery of at least O & M costs is that it is easier to obtain budget allocations for a large prestigious scheme, as counterpart funds for external financing, than to obtain the smaller amounts required year after year for operation and maintenance of an irrigation system.

The problem of cost recovery may be different for small village schemes where the arrangements for communal self-help for construction, repair and maintenance of works, have survived. Unfortunately, this is not often the case, and alternative arrangements are needed to make the group of beneficiaries responsible for repair and operation of the system, allocating works and/or cost among themselves under their own initiative.

### VI.3 **Financial Viability**

To maintain a project in operation, it must provide for financial viability for all the partners concerned.

Farmers

The necessity to assess, through farm budgets, that the required intensification is sufficently attractive to the farmer has already been mentioned. These should take account of on-farm consumption as the African traditional farmer is likely to continue to grow his own food requirements for some time. His utilization of inputs will commit him to a financial expenditure, in addition to the payment of the water charge. This represents a much higher risk than he is accustomed to take under his system of traditional agriculture, even if this includes a small plot of flood irrigation. Therefore, the technical package for intensification under irrigation should be well tested to give the farmer sufficient assurance to accept these higher risks. The pilot project concept, provided it is of sufficient size and truly representative offers a means of building the necessary knowledge and confidence.

Irrigation Entity

Once construction is completed and an entity is in charge of the operation and maintenance of the system, it must be provided with sufficient funds to cover its costs. There will be a transition period where revenue from cost recovery is insufficient because the water has not yet reached all the irrigated area, or because during the first years, to encourage farmers to use the water, a smaller water charge or none at all, is being collected. Funding for this transition period must also be provided for if necessary through an extension of the construction period financing, otherwise, when income is short, personnel will continue to be paid but repairs will not be carried out because of lack of funds for materials, fuel and occasional labour, and the irrigation system will suffer in consequence.

Where the entity in charge of the irrigation system is also entrusted with other economic activities such as supply of farm inputs and marketing of the output, it becomes easy to confuse the costs and have one activity pay for the other. There will be no incentive to achieve efficiency in operating the system as long as costs can be recovered by adjusting downwards the price paid to the farmers for paddy or cotton, but this in turn destroys former incentive to produce and to market through the entity.

## VII. HOW TO IMPROVE VIABILITY OF IRRIGATION PROJECTS

Improvements leading to better economic viability concern reduction in costs and increase in benefits. A higher participation of beneficiaries in costs would improve

financial viability of the irrigation entity and the government concerned.

Although major constraints to the mobilization of the irrigation potential are in the institutional, economic and social fields, there are technical problems which require attention. On the agronomic side, higher yields on existing and new projects would produce better returns to farmers and increased benefits, leading to improved economic viability of projects. These would require better weed control and clean, high-quality seed of rice varieties better adapted to local cropping schedules and consumer preferences, as well as improved control of, or resistance to pests and diseases related to rice, cotton, vegetables, etc.

Scheme designs and equipment better adapted to the African conditions would make it possible to hand over the schemes to irrigators earlier and more successfully, reducing the strain on government resources and ensuring greater interest and participation by the beneficiaries. Simple designs should be developed for irrigation works which could be maintained by local contractors or the irrigators themselves, and sufficiently robust to operate reasonably well under poor maintenance. Designs of pumps and small-scale equipment should also be developed or adapted, which would allow local repair and maintenance and possibly local manufacture. For large-scale projects, designs should provide for drainage even if it is to be built at a later stage when the need for drainage arises.

More systematic attempts could be made to adapt some of the low-cost small-scale systems of Asia to African conditions and materials. Also, more efforts could go into the development of low-cost irrigation systems or methods to be used for supplementary irrigation of traditional crops. Also, more systematic groundwater surveys could accelerate the spread of small-scale subsistence irrigation in semi-arid areas where it could provide some insurance against droughts and famine risks. But, as noted earlier, the existence of a number of profitable modern and mechanized irrigation systems in various African countries shows that more advanced technology may also offer solutions to successful irrigation under commercial production, especially in labour-short areas.

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(Original in English)

# NEED AND JUSTIFICATION OF IRRIGATION DEVELOPMENT

SUMMARY

REFERENCES

ANNEX 1 - Table 1: Estimated Populations
Table 2: Land Resources
Table 3: Population supporting capacity of potential rainfed area at three levels of inputs
Table 4: Surplus or deficit of potential rainfed support capacity over expected population

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**SUMMARY**

This paper examines the medium and long-term need for irrigation as a means to increase agricultural production, and possible roles of irrigation in the regions and individual countries of Africa. To that end two sets of criteria are introduced: one associated with the major constraints on agricultural development, and the second related to the future evolution of the demand for food and the extent to which physical resources are available to meet these demands.

The constraints are largely of an economic, social and institutional nature. They are particularly important in the management of modern forms of irrigation, where substantial capital and maintenance costs have to be met. Where they have been managed sufficiently competently, satisfactory results have been achieved.

Food needs provide the basis for an assessment of the potential contribution of irrigation to agricultural production. They are a general and convenient indicator because they enable the needs for biological products to be linked with population numbers. However, selecting food needs as an indicator does not necessarily imply that irrigation should be developed only to meet food needs. Irrigation may also be used to produce export crops, and to import food with part of the proceeds.

In 25 nations the resources seem technically to be sufficient to meet food needs in the foreseeable future, provided food can be moved freely within each nation and the poorer parts of the population have sufficient money to pay for what they need. Further estimates are made for the various regions and for individual countries in Sections IV and V, which indicate the times in the future at which population growth will exert particular pressures on the environmental resources.

Though irrigation capacity does not seem to be large enough on its own to meet anticipated deficits in any nation, the further development of irrigation appears fully justified in a considerable number of countries in all regions to complement rainfed production and to overcome limitations set by constraints on the physical environment. It is likely to be justified in other nations for specific and probably more limited purposes, such as the production of perishables at locations close to centres of population, and of industrial export or import-substitution crops.

The technical potential for food self-sufficiency can only be translated into practical realization through substantial development. Thus, the major constraints, which apply to both rainfed farming and irrigated agriculture must be considerably reduced. This implies (i) increased volume of demand for farm products; (ii) improved output delivery system (infrastructure, market systems, storage facilities, price management, etc.); (iii) increased availability of resources to achieve higher farm output; this is of particular importance to irrigated agriculture which requires close attention to such inputs as fertilizers, planting materials, herbicides, etc., to achieve the required investment return; (iv) more productive farming methods, if farmers are to produce a larger surplus for the market at a smaller unit cost; (v) improved knowledge systems,

including available knowledge, as well as the means to increase, disseminate, test and apply knowledge, and (vi) the accelerated development of suitable policies and practices of governments; this requires, above all, adequate understanding of development and management processes, and of the relations between development in the rural space and in other sectors of the economy.

The conditions which tend to favour irrigation development include those where (i) development prospects without irrigation are restricted, e.g. countries having substantial arid or desert lands; (ii) there is effective domestic or market demand for agricultural products which cannot be met more cheaply by other means, such as rainfed production or imports; (iii) rainfall is marginal and erratic; (iv) irrigation leads to a broad increase in economic activities; (v) land and water of suitable quality, and the means and skills to develop these, are available at acceptable cost; (vi) irrigation is expected to make a significant contribution to national food security; (vii) irrigation is likely to accelerate the development of depressed areas where this latter is a specific policy objective, and (viii) the environmental, health or other possible adverse consequences of irrigation are acceptable, or can be controlled at acceptable cost.

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## I. INTRODUCTION: SCOPE AND CONCEPT

The rates of growth of population in sub-Saharan Africa, the generally drier conditions in some more marginal areas since the late sixties, and the difficulties of food supply in some nations, have let to a generalized pessimism about the environments, climate and agricultural prospects of this large region. The achievements of India and other nations of monsoon Asia, in the face of apparently comparable or even greater difficulties, have led many to conclude that the most significant technical means open to African nations wishing to increase agricultural output is the further development of irrigation.

This paper examines the medium and long-term need for irrigation as a means to increase agricultural production, and possible roles of irrigation in the various regions and countries of Africa. To that end, two sets of criteria are introduced: (i) six main groups of constraints to the development of agricultural production in Africa, and (ii) the future evolution of the demand for food (as a general indicator of demand for agricultural production) and the extent to which physical resources are available to meet this demand.

Under a classification of countries derived from the latter criterion, an assessment is made of the potential contribution to agricultural production which can be made by irrigation to complement rainfed production and/or to overcome limitations set by constraints on the physical environment.

The assessments and suggestions made are based on data that are partially incomplete, and on studies that were still in progress at the time of writing. They are intended to outline a method of comparing environmental resources for biological production with the needs of possible future population, and to indicate present and future difficulties. They are therefore offered as a basis for thought and further study.

The present discussion is primarily concerned with future needs for, and supplies of, food. However, the data can be related to any type of biological production in which governments or producers may wish to engage, including export, import-substitution or industrial crops. Governments and individuals may well choose to use part of their rainfed and irrigated land resources to produce non-food products, and perhaps to purchase food with part or all of the proceeds.

## II. DEMOGRAPHIC AND SOCIO-ECONOMIC TRENDS

### II.1 Population Growth and Density

The total population of Africa (excluding the Republic of South Africa) in 1982 was

about 470 million people, of whom 370 million were in sub-Saharan Africa (including Sudan). The estimated growth rates of population, 1980-2000, in most African nations are between about 2.0 and 4.2% per year. The notional "plateau" population of Africa (around 2200 million, of whom more than 1800 million may be in sub-Saharan Africa, or four to five times as many as in 1982) may be reached towards the end of the twenty-first century.

Nevertheless, much of Africa is relatively sparsely populated, particularly in comparison with tropical Asia. The average population density in sub-Saharan Africa (0.16 persons per hectare of land area) is around one-tenth of that of monsoon Asia (1.64) and one-fifteenth that of India (2.46). Even at the plateau level it will be no more than half that of monsoon Asia and one third that of India at the present time. Though on average the natural environments of monsoon Asia and even of India are distinctly more favourable than those of sub-Saharan Africa, these comparisons suggest that the differences in recent development between Africa and Asia have less to do with population growth and environmental weaknesses than is often assumed. Indeed, much of sub-Saharan Africa has both satisfactory climatic resources and, at least potentially, productive soils.

### II.2 Social and Economic Change

In major parts of sub-Saharan Africa, the old subsistence society has changed substantially during the past 25 years, as development has increased the volume of non-rural activities. In many nations, if not all, rural Africans have become increasingly eager to sell production surpluses off the farm to advance their standards of life, and to save and invest.

A substantial fraction of family income (perhaps 25% to more than 50% in some nations of Southern Africa) comes from outposted family members, working off the land, often in foreign countries, but retaining their rural roots. The anticipated rates of urbanization and proportions of urban dwellers are large, but nonetheless the absolute numbers of rural people will grow for many years yet (Table 1, Annex 1).

Many African nations depend for a significant part of their foreign exchange on agricultural exports. In some nations this leads to an actual or potential conflict of interest concerning the ways in which rural resources are used. Some nations export significant quantities of non-agricultural (mostly mineral) products and are able to purchase cheap food from the international surplus. They may not yet be ready to prepare for a more self-sufficient future.

In a number of African nations, needs for fuel and timber, and for fodder, are more acute than needs for directly-consumed food. This very real difficulty has not been included in the analysis, but the data on population supporting capacity presented below will help to show where the problems are most severe since by and large, food crops compete for land and other resources with fuel and timber as well as with fodder.

Many African nations import some food from other Continents. The total net imports of cereals in sub-Saharan Africa in 1982 were 8.6 million tons, sufficient to provide the dietary energy and amino-acid needs of more than 30 million people, about 8% of the population. Considered per head of population, these imports are small compared with those of North Africa, many countries of south-west Asia, and Japan.

## III. CONSTRAINTS ON AGRICULTURAL DEVELOPMENT

The constraints on development in agriculture fall into six principal classes. They do not necessarily affect all countries, or all regions within a country, at any one time. They are offered as a checklist within which conditions for future success, or reasons for past failure, can usually be identified: (i) the volume of effective demand; (ii) the output delivery system; (iii) the resources available for development; (iv) the technical methods of production; (v) the agricultural knowledge system; and (vi) the policies and practices of governments.

### III.1 Volume of Effective Demand

Sales off the farm are the msin, and often the only way in which the rural community can earn cash to advance its living standards, and pay directly or indirectly for the maintenance of physical infrastructure and other essentials for continued development, and for schools, dispensaries and other essential welfare institutions. Poverty, by restricting the volume of effective demand, restricts output also. For this reason a policy which seeks to hold the population on the land, or to "base development on agriculture" alone, does not succeed unless thara are both sufficient rural resources and an international market for the surplus which is also sufficiently large and sufficiently reliable. This condition cannot always be guaranteed. Therefore, in practica, development in agriculture and the rural space is most likely to succeed if the national economy, as a whole, is both growing and becoming more diverse. Rural snd non-rural development, in practica, are two sides of the same coin: the one does oot progress without the other. To achieve this has saemed a difficult task for most, but not all, African governments. Perhaps the most striking exception in Africa at present is Zimbabwe.

### III.2 The Output Delivery System

Sales off tha farm are possibla only if there ia an output delivery systam (roads, vehicles, harbours, market systems, storage, processing, wholesaling, retailing, price management, etc.) to convey the signals of the market to the potential producers of marketable surpluses and to convey their products physically to thoae who wish to purchase them. Price alone has little effect if the resistances in the output channel sre large, and the other constraints ara too adverse.

Storage requires particular emphasis. Not a few current disasters hsve arisen in part becausa domestic storage systems have been disrupted, for exampla by stata action, by war, by resettlement, or by the attractions of the market itself.

Sub-Saharan Africa is in general less well aquipped for output delivery than most other major regions of the developing world. Cooversely, in all nations, in Africa and elsewhere, in which development hss been positive, the output systams are in satisfactory order. Many feel that to equip the sub-Saharan region, physically, mansgerially and economically, to deliver output is the most important contribution international donors can offar to davelopment.

### III.3 Resources for Increased Farm Output

Any increase in farm output is likely to require inputs additional to those used to meet subsistence needs. An investment in extra water is likely to require closer attention to a variety of other inputs (e.g. planting materials, fertilizers, herbicides) than investment in rainfed developmeot, because they are even more essential to ensure s return sufficient to justify and recouperate the investment in irrigation.

Land of quality, suitable for improved methoda of production and receiving adequate rainfall, is not scarce in most countries of the regioo. But thare are important exceptioos in densely populated countries aod districts in Eastern Africa, in Malawi and in parts of Zimbabwe. The most pronounced shortage in most African agricultura is of manpower. Maoy African productioo systems are so designed as to maximise the returns, not to land, but to labour st the peak period of demand. Many of the oations which have large surpluses of population-supporting capacity (Tabla 4, Annex 1) have too few people to develop their environmental resources. These difficulties ara even more marked in many irrigation systems, where timely field operations are essential for efficient use of the combined resources of land and water.

Improved seed and planting material, and mora productive and disease-tolerant animal stocks, have been developed in many African countries, but often they do not reech producers for lack of srrangements to multiply and distribute them. On tha crops side, one of the first requirements is a seed industry, supported by appropriate legislation and

monitoring arrangements. Few African nations have such industries; but those that have been established have amply proved their worth.

Fertilizers and other agricultural chemicals, are equally essential. Where these materials, and the methods for using them, have been efficiently adapted to African environments, crops and production systems, they work well. This is particularly so because they are usually applied low down on the diminishing returns curve. They are profitable provided the production system is also profitable.

In most of rural Africa, agriculture competes for resources, particularly of labour at periods of peak demand, and of cash, time and attention, with essential activities in other sectors of the rural life system. The design of innovative systems, including those based on irrigation, must take account of this competition. Domestic uses of labour, cash, time and attention will restrict the amounts that can be allocated to agricultural production.

### III.4 More Productive Farming Methods

Producers will need new methods if they are to produce a larger surplus for the market, at a smaller unit cost, so that net returns to the producers can be increased while unit costs to the consumer are held down and the product is competitive. In the earliest stages, in many rainfed areas, new methods may resemble the existing methods, which are adapted to the rest of the life system of the rural people as well as to the environment, except that they will use types of seed and planting material which are free of pests and diseases, and more resistant to or tolerant of pests and diseases than those now in use. As market needs expand, different species of plants and animals may enter the system; and more productive populations (varieties and breeds), requiring better nutrition, may be needed, along with methods of maintaining plant and animal health to achieve acceptable levels of loss at acceptable levels of cost. New equipment, new sources of power, improved genetic materials and adapted systems of production will follow. These more productive, market-directed systems will require developed systems of management, and managers who will increasingly be businessmen and women.

These considerations are important enough in rainfed developments. For irrigation they are even more important. More than one irrigated development has faltered or failed in the past because neither the appropriate technical methods nor the appropriate forms of social and individual management and control were available below the pipe outlets.

### III.5 Knowledge Systems

A knowledge system includes the stock of available knowledge, as well as the means to increase, disseminate, test and apply knowledge. Few African nations have the required data bases. In some the information has not been recorded, or has been lost; and even where it exists it is often incompletely assembled or dispersed among different agencies so that it is difficult to use. In addition, the methods for assembling, processing and analysing the information are often weak.

An important function of the knowledge system is to enhance the human resources of the nation through education, training and the dissemination of information. Among the most important beneficiaries are the rural people themselves, who need not only technical information but understanding of how to run a business and to operate in the market, if they are to use technical information productively and choose options wisely. As sales off the farm become increasingly important, the producers have to become managers in a new mode.

Many university curriculae in developing countries are versions of curriculae based on the very different environments and agricultural and socio-economic conditions of the temperate zones, where many of the teachers were trained. There is a great need for universities to teach versions of agricultural science which are appropriately adapted to their natural and human environments.

### III.6 Policies and Practices of Governments

This set of constraints arises at the national or "macro" level, but it surrounds and affects all else, including the initiatives of rural communities and individual families at the "micro" level. In relation to development in agriculture and the rural space, the main weaknesses of policy appear to be related to, among others, (i) insufficient understanding of the nature and management of the development process coupled with a tendency to regard political slogans as viable development policies; (ii) incorrect conceptions of the relations between development in the rural space and development in other sectors of the economy; (iii) unsophisticated management of foreign exchange rates; (iv) pricing policies which tax rural producers (who commit their own resources and bear all the risks) and expect them to deliver cheap food for their cousins in the city; (v) undue state interference with transport, storage, marketing and other elements of the output delivery system; and (vi) too many unsuccessful attempts at state farming.

National managerial difficulties are particularly important in relation to large-scale irrigation and the associated drainage, which require orderly and systematic operation and maintenance, and consequently a measure of discipline. This is a difficult task for most state irrigation authorities, and is part of the reason why small-scale schemes under local participatory management may be better adapted to the present stage of development than larger and more spectacular ventures.

## IV. FUTURE FOOD NEEDS AND LAND RESOURCES

For this section an assessment is made of the capacity of the countries' environments to meet increasing demands for plant biomass generated by population growth. Food needs are a convenient indicator because they enable the needs for biological products to be linked with population numbers. But the information about environmental potentials could be applied equally to the possibilities for production of cash crops of types appropriate to the different environmental conditions. Selecting food needs as an indicator does not necessarily imply that irrigation should be developed to meet food needs. It may well suit the purposes of government better to use irrigation to produce export crops, and to import food with part of the proceeds.

The environmental potentials, the future needs for food production, and the need for irrigation are assessed in Tables 1 to 4 (Annex 1). The countries in these tables have been arranged in four groups, based on geography and history, economic and political links, and present or potential communications. The Tables have been derived from various reports and studies (see list of References), supplanted by national projections of the population-supporting capacity of additional irrigated land.

The input data for the assessments were those available at the time of writing. More detailed, and more precise information is likely to emerge from ongoing studies. Therefore, the assessments are provisional only. This applies particularly to the estimates of potential irrigable land in Table 2 which are based on work still in progress by FAO. Indeed, they are far from definitive. However, since the figures refer primarily to areas that are easiest to develop for irrigated agriculture, the ongoing studies are likely to show that the real potential is greater.

The assessments and suggestions made should therefore not be read as predictions or recommendations. They are intended to do no more than outline a method of comparing environmental resources for biological production with the needs of possible future populations, and to indicate present and future difficulties. They are therefore offered as a basis for thought and further study within the nations themselves, and by the foreign and international agencies which cooperate with them.

### II.1 Population

Table 1 (Annex 1) shows the population, in millions of people, in 1982 (Ref.2) together with estimates for the years 2000 and 2025 and national projections (based on the UN forecasts) of the likely sizes of the "plateau" which may be reached towards the end of the twenty-first century. These projections are considered adequate for the semi-qualitative purposes for which they are used.

The total populationa in the regiona of Africa in 1982, 2000, 2025 and "plateau", are aummarized as follows:

Estimated populationa, by region
(from Table 1, Annex 1; millions of people)

| | 1982 | 2000 | 2025 | "plateau" |
|---|---|---|---|---|
| Africa total | 467 | 830 | 1565 | 2167 |
| North Africa | 96 | 153 | 239 | 351 |
| Sub-Saharan Africa (incl. Sudan) | 371 | 677 | 1325 | 1816 |
| Mediterranean, N and NE Africa | 115 | 185 | 295 | 436 |
| Weat Africa | 169 | 305 | 596 | 825 |
| Eaat and Central Africa | 129 | 240 | 483 | 641 |
| Southern Africa | 54 | 99 | 191 | 265 |

The detailed data are given in Table 1 (Annex 1). Columna 5 and 6 of Table 1 are iotended to show that the rural population must be expected to increaae even though the rates of urbanizatioo are greater than the population growth rates. Over the period from 1980 to 2010, rural populationa in Africa are expected to increaae from 326 to 580 millioo persons.

### IV.2 **Land Reaources**

Table 2 (Annex 1) shows the present and potential land resources. Column 1 aeta out the superficial land area of each nation. Column 2 ia the area of arable land in 1982 minus the estimated area of all forms of irrigation (i.e. modern and traditional irrigation combined, column 3). Column 4 aeta out provisional eatimatea of the areas of potential rainfed land (from Ref. 3, with later reviaiona). In the FAO study on Land, Food and Population (Ref. 8), it ia asaumed that all of the potential agricultural land would be used for the 15 major food crops or for the grasaland production of livestock. In reality, some of the land would continue to be used for other preferred food cropa that may be lesa efficient sources of dietary energy, and some for non-food crops. The changes in dieta implied by the optimum crop mix would be hard to achieve. Part of the production of cropa suitable for direct human consumption would be fed to livestock. In practice therefore the production of dietary eoergy would inevitably be less than the estimated. Moreover, the atudy restricts forestry to land unsuitable for crops or grazing, probably involving cooaiderable reductioos in the forest area and in the supply of esseotial timber and fuelwood.

Columns 5 and 6 cootain provisiooal estimatea of the areas of land that might be irrigated, in each country, with water derived from rain falling in the national territory. The figures* are based on information available at an early stage of work that is in progress (Ref.7). Revised values are expected to become available in 1986, but, since the estimates used in the table are to be considered as "base" figures, differences, if aoy, are not likely to affect the present semi-qualitative aaaessmenta.

The rationale of the estimates assumes that one half of the normal excess of precipitation over evaporation ia available for irrigation, and that irrigation efficiency is 50 percent. As a result, the effective water supply ia one quarter of the total excess.

* see also Working Document I-8: Water Resourcea and Irrigation Potential in Africa, prepared for the Consultation on Irrigation in Africa, Lomé, FAO, 1986.

"Shorter transport" in column 5 refers to land close to the source of the irrigation water: transport distances are limited to those within one agro-ecological zone in one country. "Longer transport" (column 6) refers to land further away from the source: irrigation water may be transported from one agro-ecological zone to another within a country. Column 6 includes the areas represented in column 5. Thus, the figures are based on rainfall on agro-ecological zones within countries. Obviously, this method leads to severe problems in arid and semi-arid regions, and particularly in countries in those regions that include downstream parts of major rivers. In current work an attempt is made to remedy this situation.

The present and potential areas of arable and irrigated land on the Continent are summarised as follows:

Land Resources, by region
(from Table 2, Annex 1; millions of hectares)

| | rainfed area | | irrigated area | |
|---|---|---|---|---|
| | 1982 | potential | 1982 | potential (longer transport***) |
| Africa total | 143.18 | 836.09 | 9.01 | 44.75 |
| North Africa | 18.80 | 22.46 | 3.73 | 0.42 |
| Sub-Saharan Africa (incl.Sudan) | 124.38 | 813.63 | 5.28 | 44.33 |
| Mediterranean, N and NE Africa | 29.49 | 78.68 | 5.43* | 4.86 |
| West Africa | 62.04 | 268.93 | 1.81** | 12.02 |
| East and Central Africa | 31.95 | 262.15 | 0.45 | 10.02 |
| Southern Africa | 19.70 | 226.33 | 1.32 | 17.85 |

* includes imported water
** probably includes some imported water
*** does not include imported or fossil sources of water

The figures presented are discussed in sections IV.5 and V below.

## IV.3 Population-supporting Capacity

The data of Table 2 are used to calculate Table 3 (Annex 1), which represents the population-supporting capacity of potential rainfed land, at three levels of inputs (low, intermediate and high), and of potentially irrigable land with short transport, at intermediate and high levels of inputs. The low level of inputs corresponds broadly to customary practice, with rest fallow periods to maintain soil fertility and to control pests (including diseases, weeds and other competitors with economic organisms). The intermediate level includes some modest advances, including some improved genetic material, some fertilizer (to supplement the effects of rather shorter rest fallow periods), some additional animal power and equipment, and some elementary conservation practices where these are not already part of the customary system. The high level of inputs means modern mechanized farming using systems and methods appropriate to the environment.

An eco-physiological model is used to assess potential agronomically-attainable yields from very suitable, suitable and marginally-suitable land. The human population-supporting capacity is calculated from these yields by using country-specific values of required daily calorie and protein intake to be met by the crop-animal (including range) mix appropriate to each environment: columns 1 to 3 refer to potential rainfed land, and columns 4 and 5 to people who would be supported on the land potentially irrigable with shorter transport, at the intermediate and high inputs (additional to rainfed land). Using

only the short transport figure implies that estimates of the potential contribution by irrigated land is on the conservative side.

The results produced by the eco-physiological model have been checked against actual experience on food farms and experiment stations. Expressed in terms of cereals, for all classes of cultivable land, they correspond to national averages of 280-475 kg/ha for the low level of inputs, 1200 to 1900 kg/ha for the intermediate level, and 4500-5600 kg/ha for the high level. Fallow land is included in the denominators in the first case, and to a lesser extent in the second. In the third, no more than 10% of the potentially cultivable land is assumed to be in fallow. As a consequence the average yields indicated for the low and intermediate levels are smaller than the yields estimated to be obtained per harvested hectare.

The data of Table 3 are summarised as follows:

Population-Supporting Capacity, by region
(from Table 3, Annex 1; millions of people)

| | Population supporting capacity of | | | | |
|---|---|---|---|---|---|
| | potential rainfed land at following 3 levels of inputs | | | potential "short transport" irrigable land at following levels of inputs | |
| | low | intermediate | high | intermediate | high |
| Africa total | 1029.01 | 4299.76 | 12781.81 | 256.66 | 515.70 |
| North Africa | 19.60 | 59.64 | 113.01 | 1.56 | 3.25 |
| Sub-Saharan Africa (incl. Sudan) | 1009.41 | 4240.12 | 12668.80 | 255.10 | 512.45 |
| Mediterranean, and N. E. Africa | 70.16 | 289.50 | 1140.77 | 27.96 | 56.05 |
| West Africa | 394.49 | 1518.27 | 4561.69 | 62.70 | 127.06 |
| East and Central Africa | 362.59 | 1568.98 | 3959.58 | 49.08 | 98.60 |
| Southern Africa | 201.77 | 923.01 | 3119.77 | 116.92 | 233.99 |

Though these data will be further analyzed in Section IV.4, it is already evident that the potential rainfed support capacity of the Continent, taken as a whole, is larger than the estimated populations of the future, and that there is more potentially irrigable land in sub-Saharan Africa than in the nations of the North African littoral. However, these generalizations cover substantial deficiencies of population-supporting capacity in individual nations. It should be noted that these are estimates of what is technically possible. They have not been adjusted to take account of the investment, infrastructural and institutional constraints that currently and for some time to come will limit the speed at which the technical potential may be realized. Hence the time horizons in Table 4 should not be interpreted as dates by which certain input levels will be reached. Nor should it be assumed that everybody has sufficient purchasing power to buy the food produced.

## IV.4 Excess or Deficit of Population-supporting Capacity

Table 4 (Annex 1) represents the excess (+) or deficit (-) of potential population-supporting capacity above or below the actual population in 1982 and the expected or national populations of the future (2000, 2025 and "plateau"), at the intermediate and high levels of inputs. The data are the difference between the populations of Table 1 and the potential support capacities of Table 3.

The data of Table 4 are summarized as follows:

Potential support capacity excess (+) or deficit (-); by regions
(from Table 4, Annex 1; millions of people)

| | input level | Potential support capacity (millions) | | | | |
|---|---|---|---|---|---|---|
| | | excess (+) or deficit (-) on potential rainfed land | | | | additional from short transport irrigation |
| | | 1982 (1) | 2000 (2) | 2025 (3) | "plateau" (4) | (5) |
| Africa totals | intermed. | +3832.68 | +3470.64 | +2735.48 | +2134.01 | 256.66 |
| | high | +12314.73 | +11952.67 | +11217.53 | +10616.06 | 515.70 |
| North Africa | intermed. | -36.27 | -92.85 | -179.61 | -291.36 | 1.56 |
| | high | +17.30 | -39.30 | -126.04 | -237.79 | 3.25 |
| Sub-Saharan incl. Sudan | intermed. | +3868.95 | +3563.49 | +2915.09 | +2425.37 | 255.10 |
| | high | +12297.43 | +11991.97 | +11343.57 | +10853.85 | 512.45 |
| Mediterranean, N & NE Africa | intermed. | +174.14 | +104.08 | -5.13 | -146.50 | 27.96 |
| | high | +1025.41 | +955.33 | +846.14 | +704.77 | 56.05 |
| West Africa | intermed. | +1349.74 | +1213.82 | +922.67 | +694.77 | 62.70 |
| | high | +4393.16 | +4257.24 | +3966.09 | +3738.19 | 127.06 |
| E. and Central Africa | intermed. | +1440.01 | +1328.57 | +1086.27 | +927.98 | 49.08 |
| | high | +3830.61 | +3719.17 | +3476.87 | +3318.58 | 98.60 |
| Southern Africa | intermed. | +868.79 | +824.17 | +731.67 | +657.76 | 116.92 |
| | high | +3065.55 | +3020.93 | +2928.43 | +2854.52 | 233.99 |

## IV.5 Discussion of Continental and Regional Population-supporting Capacity

Africa as a whole

Africa as a whole, and also the sub-Saharan region are potentially able to provide their own food needs from rainfed production, with or without the help of irrigation, provided that the average production reaches the intermediate or high input level in time. Yet, 19 nations will be unable to feed their growing population from their own resources at the present traditional low input level of production. The technical potential for food self-sufficiency can only be translated into practical realization through substantial development; thus, the major constraints discussed in section III, which apply to both rainfed farming and irrigated agriculture, will need to be considerably reduced. The required measures are regional or country specific as discussed in the following.

North Africa

Mediterranean (North) Africa appears unable, even at the high level of inputs, to support its population from its own environmental resources, including both rain and

irrigation, after about 1990. In this region, the largest nation, Egypt, already uses most of the resources of the Nile, but even so the five nations imported about 15 million tons of cereals and 1.5 million tons of sugar net in 1982, along with about 0.2 mllion tons of pulses. Taken together, this is sufficient to provide 2 400 kcal/head/day for more than 50 million people, nearly half of the present total population. Additional irrigation resources are scanty in the region, but the water already available could be used more efficiently. Even if this is done, however, it seems likely that part of the food needs of the population of the future will have to be met by purchased imports.

West Africa

Though there are difficulties now and in the future in individual nations, the West African region as a whole has substantial resources of both rainfed and irrigable land. However, in view of differences in the production potential and difficult communications, further development of irrigation is likely to be required in individual nations.

East and Central Africa

Similarly, though several nations are in actual or potential difficulty, the complementarities in the East and Central African region, including Zaire, are such that there could be surplus rainfed support capacity. If Zaire is excluded, however, difficulties could become apparent early in the twenty-first century unless a significant part of the area is farmed at high input levels. The difficulties arise in Burundi, Ethiopia, Kenya, Rwanda, Somalia and Uganda. The main sources of potential rainfed exportable surpluses, other than Zaire, are Tanzania and Ethiopia, provided parts of the areas of these nations are farmed at the high level of inputs. Irrigation may need to be developed further in the more marginal nations, but of these, only Kenya and Ethiopia command significant additional support capacity from this source.

Southern Africa

The Southern African region has potential rainfed surpluses, but there are potential deficits at intermediate level in the Comoros, Lesotho, and Mauritius now, in Namibia after 2000 and in Botswana and Malawi after 2025. The other nations of the region seem able in the very long-term to produce substantial rainfed surpluses, particularly Angola, Madagascar, Mozambique and Zambia, all of which have in addition important potential irrigation resources. It may be necessary to consider additional irrigation in Botswana, Malawi and Namibia, and it clearly has local advantages in Angola, Madagascar, Zimbabwe and Mozambique.

## V. NOTES ON INDIVIDUAL NATIONS

The order in which the nations are discussed in this section is related both to population pressure and to environmental resources. This is contrived by considering first those nations in which the potential output of rainfed production at average levels of agricultural technique corresponding to the intermediate level of inputs seems likely to be sufficient to sustain the "plateau" population at 2325 kcal/person/day in sub-Saharan Africa and 2400 kcal/person/day in the Mediterranean countries. Next, nations are discussed in which population will have outrun this potential support capacity before the "plateau" population is reached (after 2025). Finally, some comments are offered on those nations in which this support capacity was already too small for the population in 1982.

It is stressed that the assessments and comments made are not to be read as predictions or recommendations. They are based on incomplete data, and studies still in progress, and they are therefore offered only as a basis for thought and further study. (See also para 38 for further comments on the estimates of potential support capacity from irrigation.)

### V.1 Nations which could technically meet their food needs from national rainfed production at intermediate levels of inputs in the foreseeable future

There are 25 nations whose environmental conditions are such that an intermediate level of agricultural technique could probably provide enough food to support the popu

lations of the future (Table 4), assuming that all suitable land is developed and food can readily be moved within the country. They are (in the order in which they appear in Table 4) Sudan, Benin, Cameroon, Central African Republic, Chad, Congo, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Ivory Coast, Liberia, Sao Tomé, Sierra Leone, Togo, Equatorial Guinea, Tanzania, Zaire, Angola, Madagascar, Mozambique, Swaziland, and Zambia. Gambia could not meet its present needs from rainfed production at low levels of inputs.

Continued shortages of food in any of these nations are likely to be due, not to weaknesses in environmental resources, but to one or more of the six sets of general constraints listed in Section III. Several of the 25 nations have large areas and small populations. Communications and other components of the output delivery system are seldom strongly developed over more than a small fraction of the potential rainfed land.

However, Sudan, Chad, and Gambia have little or no land with an average reference length of rainfed growing period longer than 180 days. In Sudan, and Chad one quarter or more of the land area has an average reference length of growing period shorter than 120 days (with considerable variation and consequent risk of crop failure). Gambia, because of its shape and position, experiences some particularly dry years throughout the national domain and local irrigation seems to be fully justified.

These considerations suggest that where there is effective domestic or market demand for extra output, further development of irrigation is justified in Gambia, Chad and Sudan, and in the drier zones of other nations (Cameroon, Central African Republic, Tanzania, Madagascar, Mozambique and Zimbabwe). This will help to increase and stabilize output, assure the output of export products or of import substitution crops (for which the nation has a comparative advantage) and meet local needs for perishable products (for example milk, vegetables, flowers and fruit).

Significant possibilities of additional output from irrigation exist in all the countries listed except Liberia, Sao Tomé, Equatorial Guinea and Swaziland. In Sudan, the Central African Republic, Chad, Tanzania, Zaire, Angola, Madagascar, Mozambique and Zambia they are large enough to support at least an additional 10 million persons and in several cases many more.

### V.2 Nations which could technically meet their food needs from national rainfed production at intermediate levels of inputs until after 2025

These nations are Burkina Faso, Mali, Botswana and Malawi. None of these could meet present needs from rainfed production at low levels of inputs. Each nation has irrigation capacity sufficient to make up the anticipated deficit after 2025 at intermediate or high levels of inputs, but each could also do this by advancing the level of inputs from intermediate to high on part of the rainfed area.

However, the environments of Burkina Faso, Mali and Botswana are marginal. They include little or no land with an average reference length of rainfed growing period longer than 180 days and their average reference lengths of rainfed growing period are shorter than 120 days. Rainfall varies substantially in space and time. Extension of existing irrigation (Table 2) may therefore lead to a lessening of year-to-year risks, assure the output of export or import substitution products, and supply local needs for perishables. In Malawi the future difficulties arise from population density and growth rather than from deficiencies in the natural environment. All four nations have significant possibilities of additional output from irrigation.

### V.3 Nations which appear likely to become technically unable to meet their food needs from national rainfed production at intermediate levels of inputs at some time between 2000 and 2025

These nations are Nigeria, Senegal, Ethiopia and Uganda. None of them could meet its food needs at the present time from domestic production at low levels of inputs, and Nigeria, Senegal and Ethiopia imported substantial quantities of cereals (respectively 2.6, 0.5 and 0.3 m tons) in 1982.

Nigeria has short-transport irrigable land capable of supporting about 16 million persons at intermediate and 32 million at high levels of inputs, but the deficit in 2025 at intermediate levels of inputs seems likely to represent the requirement of about 125 million persons, equivalent to about 36 million tons of cereals. Since the country's food needs could be amply met by the improvement of rainfed production, and Nigeria should be able to produce for herself all the fuel and nitrogen fertilizer necessary to do this, one way of dealing with the problem could be to use foreign exchange for phosphate, develop a farm equipment industry (which could have regional significance in West Africa), and push on with the modernization of agriculture. Locally managed minor irrigation, which is already important will probably continue to be justified, particularly in the more marginal northern areas, for the local production of high value perishables, and perhaps for rice and some export crops.

Senegal is environmentally marginal. It has little or no land with average reference rainfed growing period longer than 180 days. The average reference length of growing season, for the country as a whole, is less than 120 days, and its reliability decreases northwards. Like Nigeria, the country is already committed to irrigation, and it has capacity for "short-transport" irrigated production sufficient for about 2 million persons at intermediate and 4.5 million at high levels of inputs. The rainfed deficit at intermediate levels of inputs in 2025 may be relatively small (-0.39 million persons), but to achieve this would require the development of the wetter southern (Casamance) region of the country and the necessary longer-range communications to support it and evacuate the produce, as well as the development of varieties and production methods suited to that region. In the circumstances, Senegal may wish to improve both rainfed and irrigated production in the more marginal northern regions, which also carry a large part of the population at the present time.

Like Senegal, part of Ethiopia's national territory is arid but a good deal is well-watered, with considerable areas of at least potentially very fertile volcanic soils. The country's capacity for short-transport irrigation is limited compared with the expected size of the population which could not be supported by rainfed agriculture at intermediate levels of inputs in 2025 (44 million persons). Irrigation may well be justified (particularly on the slopes leading down towards the Sudan). However, a major effort will probably need to be made in the improvement of rainfed output which ultimately must reach the high input level to satisfy national need for food.

Uganda is a comparatively wet country, but the rainfall is bimodal, with two dry seasons a year, over much of the national domain. Short-transport irrigation can provide additional support for no more than 6.5 million persons at high levels of inputs. The estimated deficit in rainfed supporting capacity with intermediate inputs in 2025 is equivalent to about 8 million persons. The improvement of production methods on part only of the national domain could provide all that seems likely to be needed. Further irrigation development does not seem to be essential nationally, but it will probably be justified locally to support export or import substitution crops and to meet urban demand for perishables.

**V.4 Nations which would be expected to encounter difficulties in meeting their food needs from national rainfed production at intermediate levels of inputs before 2000**

These nations are Algeria, Morocco, Mauretania, Burundi, Comoros and Namibia. None of these could meet its present food needs from domestic rainfed production at low levels of inputs. Algeria, Morocco and Mauretania imported substantial quantities of cereals (respectively 4.1, 2.0 and 0.2 m tons) in 1982.

Limited or no additional short-transport irrigation capacity appears to be available in Algeria or Morocco (though this point should be further studied, along with the possibilities of increasing the productivity of irrigation water). These nations seem likely to require increasing imports of food in the foreseeable future.

Mauritania has an arid and very uncertain environment, with an average reference length of growing season substantially less than 120 days. The country has a potential short-transport irrigable capacity for about 1 million people at high inputs, but the deficits of rainfed supporting capacity at intermediate levels of input would be of that

size by 2000. Even at high inputs there would be a rainfed deficit of 0.6 million when the "plateau" population is reached. Therefore, Mauretania will justifiably wish to develop both irrigated and rainfed production as far as possible, but it is unlikely that it will be able to meet all future needs from within her own boundaries.

Short-transport irrigation capacity in Burundi is small: enough to sustain about 0.4 million persons at high inputs, against a deficit in rainfed support capacity at intermediate inputs of 2.4 million in 2000 and 0.6 million at high inputs in 2025. The country does not seem likely to be able to resolve its future food difficulties within its own boundaries. Irrigation seems to be fuly justified, but in addition Burundi wil require additional supplies from other nations.

The environment of Namibia is marginal (average length of growing season substantially less than 120 days) and very variable between places and years. At intermediate levels of inputs, deficits in rainfed supporting capacity will increase to more than 2 million persons by 2025. The short-transport irrigation potential could support an additional 1.2 milion persons at high levels of inputs, but high input methods on the rainfed land could support an additional 20 - 30 million people. Provided sufficient foreign exchange continues to be available to purchase inputs, Namibia could feed itself if it had to, and also export animal products. To that end, the development of both irrigation and high-input agriculture may need to be considered.

**V.5 Nations which could not meet their food needs from national rainfed production at intermediate level of inputs at the present time**

These nations are Egypt, Libya, Tunisia, Niger, Kenya, Rwanda, Somalia, Lesotho, and Mauritius.

Egypt and Libya have probably developed their non-fossil irrigation resources to maximum area already, though further gains are probably possible through more efficient use of water. The rainfed resources of these nations cannot provide a sufficient addition to meet the future needs of their people. They already import substantial quantities of food (6.7 and 1.0 million tons of cereals respectively in 1982) and this pattern must be expected to continue.

Tunisia has more substantial rainfed prospects and short-transport potential irrigation sufficient to support 1.75 million people, but it seems inevitable that this country too will have to import large quantities of food.

Niger, Kenya, Somalia and Lesotho have little or no land with an average reference growing period longer than 180 days, and their average reference lengths of growing period are all less than 120 days. Variability in rainfall is very large in these countries. Rainfall is bimodal in Kenya and Somalia. In Lesotho the growing season is also limited by cold temperatures.

The short-transport irrigation potential of Niger may be sufficient to sustain 2.5 million persons at the high input level. The deficit at intermediate levels of inputs, assuming all potential rainfed land is used, is now already more than 3 million persons. At the "plateau" level it would be more than 25 million. However, modern agriculture on part only of the potential rainfed land could produce enough to meet essential dietary needs. Irrigation seems to be justified up to the limit available, including whatever additional water can be obtained from the Niger River, but food supplies will have to be supplemented by modern farming together with imports.

Ninety percent of Kenya is arid. With all potential rainfed land developed under high input agriculture, the deficit in support capacity seems likely to exceed 30 million people by 2025. Irrigation could support perhaps 9 million of these. But the data of Table 4 show that after 2000 Kenya will not be able to support itself by domestic production and will require imports.

The caee of Somalia is in many reepecte eimilar. Even if all the potential rainfed land ia farmed at a high level of inpute, the deficit in aupporting capacity will be 0.7 million people in 2000 and 7 million people in 2025. Irrigation potential eeems to be enough, at best, to sustain no more than 2.3 million people. Irrigation is clearly justified.

Mauritius is a special caee: a small relatively denaely populated ieland which developed a complex export-directed sugar economy in colonial times. It does not appear to have any additional short-transport irrigation potential. Mauritius could not support her preeent population from domeatic supplies even at the high level of inpute.

## VI. CONDITIONS FOR IRRIGATION DEVELOPMENT AND BROAD CONCLUSIONS

### VI.1 Conditione

The population eupport capacity that could be provided by irrigation constitutea a basic factor in the plaoning of both rainfed and irrigation development. Obviously, there are a large number of ecooomic, physiographic, social, technical and political coneiderations that will influence decision, particularly regarding the shorter-term planniog. These are diecueeed in other working documents. In this section only eome particular considerations and cooditions are briefly mentioned.

Conditions that tend to favour irrigation development include thoae where:

- development prospecte without irrigation are restricted, for example where a aubstaotial part of the territory of a nation or dietrict is arid or deeert but land, power, knowledge and other requirements are available. The loog history of Egypt and the more recent development of irrigation in the Sudan Gezira are exsmplee;
- there is effective domestic or market demand (at home or abroad) for agricultural products, which cannot be met more cheaply by other means (euch ae development of rainfed production, or by importe where exports provide a aufficient balance of payments). It is the difficult task of government to decide how large a degree of self-sufficieocy a nation can afford;
- rainfall is not only marginal, but also fluctuates so much more from year to year in amount and diatribution, that irrigation ia needed to make the annual aupply of food and other products less precarious. Irrigated yields are usually larger than rainfed yielda, eo that, together with atorage of products, the supply may be more eecure;
- irrigation leads to a broad increase in economic activities, and offers improvemeote in income and conditiona of life of a sufficiently large number of rural people at costs which can be justified in terms of opportunitiee foregone and of equity. There muet always be eome doubt about the juetifications of opening up and developing a sparsely populated and marginal area for irrigatioo, unless the water eupply ie both large and secure and there ia a sufficiently profitable and secure market for the produce. Governments may well prefer to uee irrigation to increaee output in regioos where there are people, eettlemente aod communications already;
- land and water of suitable quality, and the inpute and technical methods of production needed to make profitable uee of them, are available at acceptable cost, without uoduly compromieing the longer term future. Many governmente do not have the necessary information about land, climate, technical alternativee, economic, social and managerial poeeibilitiee, and the techniquee for handling the informatioo in making decisions. To develop irrigation, both thia information and the people competent to operate them are neceeeary;
- the constrainte discussed in Section III do not impoee unaccepteble coete or technical, political and managerial difficulties. Among theee, profitable methode of production, effective output delivery syatems, and appropriate aocial and political organizatioo, are likely to be particularly important;

- there are no more profitable ways of using land and water, and the resources needed to develop irrigation (for example the generation of power);

- irrigation is expected to make a significant contribution to national food security;

- irrigation is likely to accelerate the development of depressed areas where this latter is a specific policy objective;

- the environmental, health or other possible adverse consequences of irrigation are acceptable, or can be controlled at acceptable cost.

A consideration of particular interest in the planning of irrigation development in countries having little irrigation experience is related to the period of time needed to build an adequate development capacity. Experience shows that sustained successful irrigation can only be achieved if government, farmers and private enterprise have acquired the experience and skills to plan, develop, implement, use and manage the irrigation system efficiently. This requires a learning process for all involved that is often considered to take at least two decades. This implies that a gradual build-up of skills through research, pilot projects, farmers involvement, training and measures in the institutional sphere must be initiated now if adequate capacity for irrigation development is considered necessary early in the next century.

## VI.2 **Broad Conclusions**

The following broad conclusions emerge from the discussions:

a) the considerable difficulties in relation to food and other agricultural products which confront several African nations at present will, if nothing is done, increase substantially as population grows, even though the present and likely future densities of population in most African nations are considerably smaller than those of many nations in other regions of the developing world;

b) more productive methods of rainfed agriculture are already helping to offset these difficulties in some nations;

c) further advances in rainfed production methods (which are technically and environmentally feasible, though the costs and returns wil have to be studied with care), will be necessary in all nations. They would eliminate the foreseeable difficulties of food supply in most nations and significantly lessen them in the remainder;

d) although the technical prospects for irrigation are relatively limited in many of the nations that need it most, and although irrigation may entail important environmental, social and economic difficulties, it does indeed have a significant and even essential part to play in a considerable number of countries; and

e) because some nations do not seem likely to be able to resolve their problems at acceptable cost within their own boundaries, economically and politically viable means of transferring agricultural products between African nations will be required. Investment planning for agriculture for the future whether rainfed or, more important, under irrigation should take into account the development of communications systems between as well as within nations, including the physical infrastructure for storage, processing and transport.

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**REFERENCES**


1. Land Resources for Populations of the Future, Report on FAO/UNFPA Expert Consultation, FAO, Rome, 1980.

2. FAO Production Yearbook 1983, vol. 37

3. Agro-ecological Zones Project, vol. 1-4, World Soil Resources Report 48/1-4, FAO Rome, 1978-80.

4. World Population Prospects, amended in 1980. Dept. of Economic and Social Affairs, UN, New York, 1981.

5. Demographic yearbook 1983, 35th issue, UN Dept. of Int. Economic and Social Affairs, New York, 1985.

6. Africa Food Study, FAO, 1985-86 (in progress).

7. Water Resources and Irrigation Potential, FAO, 1985-86 (study in progress).

8. Land, Food and Population, FAO Conference Paper (C 83/18), 1983.

**ANNEX 1**

Table 1: Estimated populations (millions of people)

| | Total populations | | | | "rural" populations | |
|---|---|---|---|---|---|---|
| | 1982 (1) | 2000 (2) | 2025 (3) | "plateau" (4) | 1980 (5) | 2010 (6) |
| AFRICA TOTAL | 467.418 | 829.552 | 1564.727 | 2166.750 | 325.563 | 580.477 |
| MEDITERRANEAN, NORTH AND NORTH EAST AFRICA | | | | | | |
| TOTAL | 115.362 | 185.442 | 294.629 | 436.000 | 60.435 | 91.891 |
| Algeria | 20.293 | 35.194 | 57.344 | 80.000 | 7.306 | 8.764 |
| Egypt | 44.058 | 65.200 | 97.391 | 150.000 | 22.812 | 30.054 |
| Libya | 3.221 | 6.072 | 11.057 | 16.000 | 1.290 | 1.614 |
| Morocco | 21.667 | 36.325 | 59.859 | 85.000 | 11.920 | 17.518 |
| Sudan | 19.451 | 32.926 | 55.379 | 85.000 | 14.059 | 20.871 |
| Tunisia | 6.672 | 9.725 | 13.599 | 20.000 | 3.048 | 3.070 |
| WEST AFRICA | | | | | | |
| TOTAL | 168.861 | 304.862 | 596.054 | 824.500 | 123.276 | 226.339 |
| Benin | 3.754 | 6.381 | 12.166 | 18.000 | 2.402 | 3.338 |
| Burkina Faso | 7.285 | 10.542 | 19.488 | 30.000 | 5.741 | 11.482 |
| Cameroon | 8.865 | 14.424 | 25.234 | 44.000 | 5.590 | 6.313 |
| Cape Verde | 0.335 | 0.382 | 0.457 | 1.000 | 0.283 | 0.361 |
| Central African Rep. | 2.405 | 3.736 | 6.724 | 12.000 | 1.354 | 1.724 |
| Chad | 4.643 | 7.304 | 13.115 | 20.000 | 3.680 | 5.521 |
| Congo | 1.621 | 2.646 | 5.050 | 8.000 | 0.959 | 1.511 |
| Gabon | 1.074 | 1.611 | 3.273 | 5.000 | 0.690 | 0.837 |
| Gambia | 0.635 | 0.898 | 1.500 | 3.000 | 0.475 | 0.693 |
| Ghana | 12.462 | 21.923 | 37.748 | 60.000 | 7.349 | 11.973 |
| Guinea | 5.285 | 7.935 | 13.906 | 25.000 | 3.911 | 6.012 |
| Guinea Bissau | 0.594 | 1.241 | 2.141 | 3.000 | 0.617 | 0.834 |
| Ivory Coast | 8.568 | 15.581 | 28.134 | 43.000 | 5.188 | 7.969 |
| Liberia | 2.113 | 3.564 | 6.763 | 11.000 | 1.218 | 1.972 |
| Mali | 6.940 | 12.363 | 21.368 | 35.000 | 5.726 | 9.932 |
| Mauretania | 1.730 | 2.999 | 5.901 | 9.000 | 1.192 | 1.589 |
| Niger | 5.646 | 9.750 | 18.940 | 28.000 | 4.610 | 8.699 |
| Nigeria | 82.392 | 161.930 | 338.105 | 410.000 | 64.112 | 133.429 |

Note: Réunion, as a Department outre-mer, is included in these tables for geographical completeness.

Table 1: Populations (continued)

| | Total populations | | | | "rural" populations | |
|---|---|---|---|---|---|---|
| | 1982 (1) | 2000 (2) | 2025 (3) | "plateau" (4) | 1980 (5) | 2010 (6) |
| Sao Tome | 0.086 | 0.149 | 0.284 | 0.500 | 0.057 | 0.083 |
| Senegal | 5.968 | 10.036 | 18.928 | 30.000 | 3.542 | 5.119 |
| Sierra Leone | 3.672 | 4.868 | 7.805 | 15.000 | 2.487 | 3.115 |
| Togo | 2.788 | 4.599 | 9.024 | 14.000 | 2.093 | 3.833 |
| EAST AND CENTRAL AFRICA | | | | | | |
| TOTAL | 128.971 | 240.408 | 482.708 | 641.000 | 99.532 | 200.595 |
| Burundi | 4.460 | 6.951 | 11.047 | 18.000 | 3.959 | 8.250 |
| Equatorial Guinea | 0.381 | 0.559 | 0.937 | 2.000 | 0.163 | 0.173 |
| Ethiopia | 32.925 | 58.407 | 111.983 | 165.000 | 27.377 | 48.362 |
| Kenya | 17.864 | 38.534 | 82.850 | 90.000 | 14.390 | 36.951 |
| Rwanda | 5.109 | 10.565 | 22.161 | 26.000 | 4.923 | 13.063 |
| Somalia | 5.116 | 7.079 | 13.204 | 20.000 | 3.221 | 4.313 |
| Tanzania | 19.111 | 39.129 | 83.895 | 100.000 | 16.639 | 37.605 |
| Uganda | 14.057 | 26.774 | 52.334 | 70.000 | 11.607 | 25.550 |
| Zaire | 29.948 | 52.410 | 104.387 | 150.000 | 17.253 | 26.328 |
| SOUTHERN AFRICA | | | | | | |
| TOTAL | 54.224 | 98.840 | 191.336 | 265.250 | 42.320 | 71.652 |
| Angola | 7.452 | 13.234 | 24.473 | 37.000 | 6.101 | 9.736 |
| Botswana | 0.859 | 1.865 | 4.057 | 5.000 | 0.769 | 1.562 |
| Comoros | 0.380 | 0.715 | 1.076 | 1.500 | 0.347 | 0.615 |
| Lesotho | 1.409 | 2.251 | 4.055 | 7.000 | 1.279 | 2.468 |
| Madagascar | 9.223 | 15.552 | 29.663 | 45.000 | 7.063 | 12.371 |
| Malawi | 6.566 | 11.669 | 23.187 | 33.000 | 5.392 | 11.614 |
| Mauritius | 0.992 | 1.298 | 1.606 | 2.000 | 0.456 | 0.395 |
| Mozambique | 11.052 | 21.779 | 39.705 | 55.000 | 10.508 | 14.266 |
| Namibia | 1.070 | 2.382 | 4.286 | 5.500 | 0.739 | 0.880 |
| Reunion | 0.540 | 0.685 | 0.825 | 1.250 | 0.237 | 0.190 |
| Swaziland | 0.591 | 1.041 | 1.943 | 3.000 | 0.448 | 0.668 |
| Zambia | 6.163 | 11.237 | 23.800 | 30.000 | 3.232 | 4.530 |
| Zimbabwe | 7.927 | 15.132 | 32.660 | 40.000 | 5.749 | 12.357 |

Table 2: Land Resources (millions of hectares)

| | Total land area (1) | Rainfed area 1982 (2) | Irrigated area 1982 (3) | Potential areas of rainfed land (4) | irrigable land with shorter (5) | transport*** longer (6) |
|---|---|---|---|---|---|---|
| AFRICA TOTAL | 2851.6 | 143.18 | 9.01 | 836.09 | 33.95 | 44.75 |
| MEDITERRANEAN, NORTH AND NORTH EAST AFRICA | | | | | | |
| TOTAL | 824.0 | 29.49 | 5.43* | 78.68 | 3.43 | 4.86 |
| Algeria | 237.8 | 6.53 | 0.35 | 7.51 | 0.06 | 0.13 |
| Egypt | 99.1 | | 2.47 | 1.04 | | |
| Libya | 175.9 | 1.53 | 0.23 | 2.00 | | 0.10 |
| Morocco | 44.4 | 7.43 | 0.50 | 7.41 | | 0.12 |
| Sudan | 250.5 | 10.69 | 1.70 | 56.22 | 3.30 | 4.44 |
| Tunisia | 16.3 | 3.31 | 0.18 | 4.50 | 0.07 | 0.07 |
| WEST AFRICA | | | | | | |
| TOTAL | 907.6 | 62.04 | 1.81** | 268.93 | 7.97 | 12.02 |
| Benin | 11.3 | 1.34 | 0.02 | 6.35 | 0.09 | 0.09 |
| Burkina Faso | 27.1 | 2.59 | 0.03 | 10.71 | 0.35 | 0.72 |
| Cameroon | 47.2 | 5.89 | 0.02 | 31.54 | 0.24 | 0.37 |
| Cape Verde | 0.4 | 0.04 | 0.002 | 0.04 | | |
| Central African Rep. | 62.3 | 1.88 | | 35.83 | 1.90 | 1.95 |
| Chad | 127.5 | 3.10 | 0.05 | 17.04 | 1.20 | 1.42 |
| Congo | 34.2 | 0.65 | 0.01 | 21.65 | 0.34 | 0.36 |
| Gabon | 26.2 | 0.28 | | 12.88 | 0.44 | 0.44 |
| Gambia | 1.1 | 0.13 | 0.03 | 0.53 | 0.07 | 0.07 |
| Ghana | 22.6 | 1.04 | 0.06 | 10.96 | 0.12 | 0.12 |
| Guinea | 24.6 | 1.32 | 0.18 | 7.51 | 0.15 | 0.15 |
| Guinea Bissau | 3.6 | 0.26 | | 2.03 | 0.07 | 0.07 |
| Ivory Coast | 31.5 | 2.73 | 0.06 | 14.09 | 0.13 | 0.13 |
| Liberia | 11.1 | 0.11 | 0.02 | 5.24 | | |
| Mali | 124.0 | 1.91 | 0.15 | 16.79 | 0.34 | 1.49 |
| Mauretania | 103.1 | 0.18 | 0.02 | 1.40 | 0.04 | 0.04 |
| Niger | 126.1 | 3.63 | 0.02 | 11.76 | 0.10 | 0.10 |
| Nigeria | 91.2 | 27.06 | 0.84 | 47.90 | 2.00 | 3.73 |
| Sao Tome | 0.1 | 0.001 | | 0.06 | | |
| Senegal | 19.6 | 5.03 | 0.19 | 9.72 | 0.18 | 0.58 |

Table 2: Land Resources (continued)

| | Total land area (1) | Rainfed area 1982 (2) | Irrigated area 1982 (3) | Potential areas of rainfed land (4) | irrigable land with shorter (5) | transport*** longer (6) |
|---|---|---|---|---|---|---|
| Sierra Leone | 7.2 | 1.52 | 0.10 | 2.76 | 0.10 | 0.10 |
| Togo | 5.6 | 1.35 | 0.01 | 2.14 | 0.09 | 0.09 |
| EAST AND CENTRAL AFRICA | | | | | | |
| TOTAL | 590.4 | 31.95 | 0.45 | 262.15 | 8.01 | 10.02 |
| Burundi | 2.6 | 1.09 | 0.01 | 0.99 | 0.05 | 0.05 |
| Equatorial Guinea | 2.8 | 0.13 | | 1.85 | 0.10 | 0.10 |
| Ethiopia | 120.8 | 13.14 | 0.11 | 24.94 | 0.67 | 1.91 |
| Kenya | 57.0 | 1.85 | 0.05 | 6.72 | 0.35 | 0.61 |
| Rwanda | 2.5 | 0.74 | 0.01 | 0.90 | 0.04 | 0.04 |
| Somalia | 63.6 | 1.02 | 0.08 | 1.74 | 0.09 | 0.09 |
| Tanzania | 88.9 | 4.00 | 0.14 | 36.60 | 2.30 | 2.74 |
| Uganda | 20.0 | 4.17 | 0.01 | 10.75 | 0.41 | 0.48 |
| Zaire | 232.2 | 5.81 | 0.04 | 177.66 | 4.00 | 4.00 |
| SOUTHERN AFRICA | | | | | | |
| TOTAL | 529.6 | 19.70 | 1.32 | 226.33 | 14.54 | 17.85 |
| Angola | 123.9 | 2.94 | 0.01 | 77.31 | 6.70 | 7.94 |
| Botswana | 60.0 | 1.35 | 0.01 | 1.68 | 0.10 | 0.10 |
| Comoros | 0.2 | 0.02 | | 0.10 | | |
| Lesotho | 3.0 | 0.23 | | 0.34 | 0.01 | 0.02 |
| Madagascar | 58.0 | 1.55 | 0.96 | 32.77 | 1.20 | 1.47 |
| Malawi | 8.8 | 2.29 | 0.02 | 4.12 | 0.29 | 0.29 |
| Mauritius | 0.2 | 0.09 | 0.01 | 0.10 | | |
| Mozambique | 78.3 | 2.78 | 0.07 | 41.43 | 2.40 | 3.63 |
| Namibia | 82.3 | 0.65 | 0.01 | 0.51 | 0.05 | 0.05 |
| Reunion | 0.3 | 0.05 | | 0.12 | | |
| Swaziland | 1.7 | 0.07 | 0.06 | 0.86 | 0.01 | 0.01 |
| Zambia | 74.3 | 5.13 | 0.02 | 51.08 | 3.50 | 3.93 |
| Zimbabwe | 38.6 | 2.55 | 0.15 | 15.91 | 0.28 | 0.41 |

*: includes imported water; **: probably includes some imported water;
***: does not include imported or fossil sources of water

Table 3: Population-supporting capacity of potential rainfed area at three levels of inputs, and additional population-supporting capacity of land potentially irrigable with short transport of water at intermediate and high levels of inputs; millions of people.

* Countries whose populations could not be supported on rainfed agriculture at low inputs in 1982.

Population supporting capacity of

| | potential rainfed land at following 3 levels of inputs | | | Potential "short transport" irrigable land at following 2 levels of inputs | |
|---|---|---|---|---|---|
| | low | intermediate | high | intermediate | high |
| | (1) | (2) | (3) | (4) | (5) |
| AFRICA TOTAL | 1029.01 | 4299.76 | 12781.81 | 256.66 | 515.70 |
| MEDITERRANEAN, NORTH AND NORTH EAST AFRICA | | | | | |
| TOTAL | 70.16 | 289.50 | 1140.77 | 27.96 | 56.05 |
| Algeria* | 4.90 | 22.50 | 44.70 | 0.72 | 1.50 |
| Egypt* | 0.68 | 3.12 | 6.19 | | |
| Libya* | 0.49 | 2.39 | 5.29 | | |
| Morocco* | 12.48 | 26.78 | 46.48 | | |
| Sudan | 50.56 | 229.86 | 1027.56 | 26.40 | 52.80 |
| Tunisia* | 1.05 | 4.85 | 10.55 | 0.84 | 1.75 |
| WEST AFRICA | | | | | |
| TOTAL | 394.49 | 1518.27 | 4561.69 | 62.70 | 127.06 |
| Benin | 6.22 | 27.60 | 102.12 | 0.32 | 0.64 |
| Burkina Faso* | 5.38 | 26.38 | 136.48 | 2.80 | 5.60 |
| Cameroon | 76.72 | 209.12 | 612.82 | 1.92 | 3.84 |
| Central African Rep. | 44.80 | 211.80 | 597.70 | 15.20 | 30.40 |
| Chad | 13.40 | 69.60 | 306.90 | 9.60 | 19.20 |
| Congo | 40.36 | 162.36 | 405.36 | 2.22 | 5.44 |
| Gabon | 41.80 | 126.80 | 280.50 | 1.76 | 3.52 |
| Gambia* | 0.64 | 3.24 | 11.04 | 0.56 | 1.12 |
| Ghana | 20.06 | 88.26 | 242.76 | 0.96 | 1.92 |
| Guinea | 14.28 | 53.28 | 173.88 | 0.60 | 1.20 |
| Guinea Bissau | 2.30 | 9.00 | 29.30 | 0.28 | 0.56 |
| Ivory Coast | 47.76 | 164.46 | 372.36 | 1.04 | 2.08 |

Table 3: Population supporting capacity (continued)

| | Population supporting capacity of | | | | |
|---|---|---|---|---|---|
| | potential rainfed land at following 3 levels of inputs | | | potential short transport irrigable land at following 2 levels of inputs | |
| | low | intermediate | high | intermediate | high |
| Liberia | 9.42 | 47.72 | 126.62 | | |
| Mali* | 7.11 | 34.41 | 169.31 | 4.08 | 8.50 |
| Mauretania* | 0.46 | 1.96 | 8.36 | 0.48 | 1.00 |
| Niger* | 0.74 | 2.54 | 43.24 | 1.20 | 2.50 |
| Nigeria* | 50.74 | 214.84 | 736.74 | 16.00 | 32.00 |
| Sao Tome | 0.20 | 0.60 | 0.80 | | |
| Senegal* | 3.54 | 18.54 | 103.64 | 2.16 | 4.50 |
| Sierra Leone | 4.70 | 27.40 | 49.60 | 0.80 | 1.60 |
| Togo | 3.86 | 18.36 | 52.16 | 0.72 | 1.44 |
| EAST AND CENTRAL AFRICA | | | | | |
| TOTAL | 362.59 | 1568.98 | 3959.58 | 49.08 | 98.60 |
| Burundi* | 0.86 | 4.56 | 10.46 | 0.20 | 0.40 |
| Equatorial Guinea | 3.90 | 11.50 | 33.70 | 0.40 | 0.80 |
| Ethiopia* | 16.15 | 67.65 | 307.85 | 5.36 | 10.72 |
| Kenya* | 2.90 | 11.30 | 51.00 | 4.20 | 8.75 |
| Rwanda* | 0.66 | 3.56 | 8.16 | 0.16 | 0.32 |
| Somalia* | 0.78 | 1.87 | 6.37 | 1.08 | 2.25 |
| Tanzania | 34.64 | 143.74 | 500.44 | 18.40 | 36.80 |
| Uganda* | 10.96 | 43.96 | 154.06 | 3.28 | 6.56 |
| Zaire | 291.74 | 1280.84 | 2887.54 | 16.00 | 32.00 |
| SOUTHERN AFRICA | | | | | |
| TOTAL | 201.77 | 923.01 | 3119.77 | 116.92 | 233.99 |
| Angola | 53.16 | 278.80 | 931.26 | 53.60 | 107.20 |
| Botswana* | 0.86 | 4.76 | 46.26 | 1.20 | 2.50 |
| Comoros* | 0.10 | 0.50 | 1.00 | | |
| Lesotho* | 0.60 | 1.40 | 3.10 | 0.08 | 0.16 |
| Madagascar | 43.02 | 186.82 | 554.02 | 9.60 | 19.20 |
| Malawi* | 6.62 | 24.22 | 57.02 | 2.32 | 4.64 |
| Mauritius* | 0.33 | 0.93 | 0.63 | | |
| Mozambique | 37.92 | 156.42 | 534.72 | 19.20 | 38.40 |
| Namibia* | 0.66 | 2.06 | 31.96 | 0.60 | 1.25 |
| Reunion* | 0.10 | 0.50 | 1.60 | | |
| Swaziland* | 0.56 | 3.36 | 6.26 | 0.08 | 0.16 |
| Zambia | 48.82 | 215.82 | 766.52 | 28.00 | 56.00 |
| Zimbabwe | 9.02 | 47.42 | 185.42 | 2.24 | 4.48 |

Table 4: Excess (+) or deficit (-) of potential rainfed support capacity over expected population, with 2 input levels: millions of persons. Additional support capacity from land irrigable with short transport of water (from Table 3) is also shown.

*Countries whose populations could not be supported on rainfed agriculture with low inputs in 1982.

| | input level | Potential support capacity (millions) excess (+) or deficit (-) on potential rainfed land 1982 (1) | 2000 (2) | 2025 (3) | "plateau" (4) | additional from "short transport" irrigation (5) |
|---|---|---|---|---|---|---|
| AFRICA TOTALS | intermed. | +3832.68 | +3470.64 | +2735.48 | +2134.01 | 256.66 |
| | high | +12314.73 | +11952.67 | +11217.53 | +10616.06 | 515.70 |
| MEDITERRANEAN, NORTH AND NORTH EAST AFRICA | | | | | | |
| TOTALS | intermed. | +174.14 | +104.08 | -5.13 | -146.50 | 27.96 |
| | high | +1025.41 | +955.33 | +846.14 | +704.77 | 56.05 |
| Algeria* | intermed. | +2.21 | -12.69 | -34.84 | -57.50 | 0.72 |
| | high | +24.41 | +9.51 | -12.64 | -35.30 | 1.50 |
| Egypt* | intermed. | -40.94 | -62.08 | -94.27 | -146.88 | |
| | high | -37.87 | -59.01 | -91.20 | -143.81 | |
| Libya* | intermed. | -0.83 | -3.66 | -8.67 | -13.61 | |
| | high | +2.07 | -0.78 | -5.77 | -10.71 | |
| Morocco* | intermed. | +5.11 | -9.54 | -33.08 | -58.22 | |
| | high | +24.81 | +10.16 | -13.38 | -38.52 | |
| Sudan | intermed. | +210.41 | +196.93 | +174.48 | +144.86 | 26.40 |
| | high | +1008.11 | +994.63 | +972.18 | +942.56 | 52.80 |
| Tunisia* | intermed. | -1.82 | -4.88 | -8.75 | -15.15 | 0.84 |
| | high | +3.88 | +0.82 | -3.05 | -9.45 | 1.75 |
| WEST AFRICA | | | | | | |
| TOTALS | intermed. | +1349.74 | +1213.82 | +922.67 | +694.77 | 62.70 |
| | high | +4393.16 | +4257.24 | +3966.09 | +3738.19 | 127.06 |
| Benin | intermed. | +23.85 | +21.22 | +15.43 | +9.60 | 0.32 |
| | high | +98.37 | +95.74 | +89.95 | +84.12 | 0.64 |
| Burkina Faso* | intermed. | +19.10 | +15.84 | +6.89 | -3.62 | 2.80 |
| | high | +129.20 | +125.94 | +116.99 | +106.48 | 5.60 |
| Cameroon | intermed. | +200.26 | +194.70 | +183.89 | +165.12 | 1.92 |
| | high | +603.96 | +598.40 | +587.59 | +568.82 | 3.84 |

Table 4: Surplus or deficit supporting capacity (continued)

| | input level | Potential support capacity (millions) excess (+) or deficit (-) on potential rainfed land 1982 (1) | 2000 (2) | 2025 (3) | "plateau" (4) | additional from short transport irrigation (5) |
|---|---|---|---|---|---|---|
| Central African Republic | intermed. | +209.40 | +208.06 | +205.08 | +199.80 | 15.20 |
| | high | +595.30 | +593.96 | +590.98 | +585.70 | 30.40 |
| Chad | intermed. | +64.96 | +62.30 | +56.48 | +49.60 | 9.60 |
| | high | +302.26 | +299.60 | +293.78 | +286.90 | 19.20 |
| Congo | intermed. | +160.74 | +159.71 | +157.31 | +154.36 | 2.22 |
| | high | +403.74 | +402.71 | +400.31 | +397.36 | 5.44 |
| Gabon | intermed. | +125.73 | +125.19 | +123.53 | +121.80 | 1.76 |
| | high | +279.43 | +278.89 | +277.23 | +275.50 | 3.52 |
| Gambia* | intermed. | +2.60 | +2.34 | +1.74 | +0.24 | 0.56 |
| | high | +10.40 | +10.14 | +9.54 | +8.04 | 1.12 |
| Ghana | intermed. | +75.80 | +66.34 | +50.51 | +28.26 | 0.96 |
| | high | +230.30 | +220.84 | +205.01 | +182.76 | 1.92 |
| Guinea | intermed. | +48.00 | +45.34 | +39.37 | +28.28 | 0.60 |
| | high | +168.60 | +165.94 | +159.97 | +148.88 | 1.20 |
| Guinea Bissau | intermed. | +8.41 | +7.76 | +6.86 | +6.00 | 0.28 |
| | high | +28.71 | +28.06 | +27.16 | +26.30 | 0.56 |
| Ivory Coast | intermed. | +155.89 | +148.88 | +136.33 | +121.46 | 1.04 |
| | high | +363.79 | +356.78 | +344.23 | +329.36 | 2.08 |
| Liberia | intermed. | +45.61 | +44.16 | +40.96 | +36.72 | |
| | high | +124.51 | +123.06 | +119.86 | +115.62 | |
| Mali* | intermed. | +27.47 | +22.05 | +13.04 | -0.59 | 4.08 |
| | high | +162.37 | +156.95 | +147.94 | +134.31 | 8.50 |
| Mauretania* | intermed. | +0.23 | -1.04 | -3.94 | -7.04 | 0.48 |
| | high | +6.63 | +5.36 | +2.46 | -0.64 | 1.00 |
| Niger* | intermed. | -3.11 | -7.21 | -16.40 | -25.46 | 1.20 |
| | high | +37.59 | +33.49 | +24.30 | +15.24 | 2.50 |
| Nigeria* | intermed. | +132.45 | +52.91 | -123.26 | -195.16 | 16.00 |
| | high | +654.35 | +574.81 | +398.64 | +326.74 | 32.00 |
| Sao Tome | intermed. | +0.51 | +0.45 | +0.32 | +0.10 | |
| | high | +0.71 | +0.65 | +0.52 | +0.30 | |
| Senegal* | intermed. | +12.57 | +8.50 | -0.39 | -11.46 | 2.16 |
| | high | +97.67 | +93.60 | +84.71 | +73.64 | 4.50 |
| Sierra Leone | intermed. | +23.73 | +22.53 | +19.60 | +12.40 | 0.80 |
| | high | +45.93 | +44.73 | +41.80 | +34.60 | 1.60 |
| Togo | intermed. | +15.57 | +13.76 | +9.34 | +4.36 | 0.72 |
| | high | +49.37 | +47.56 | +43.14 | +38.16 | 1.44 |
| EAST AND CENTRAL AFRICA | | | | | | |
| TOTALS | intermed. | +1440.01 | +1328.57 | +1086.27 | +927.98 | 49.08 |
| | high | +3830.61 | +3719.17 | +3476.87 | +3318.58 | 98.60 |
| Burundi* | intermed. | +0.10 | -2.39 | -6.49 | -13.44 | 0.20 |
| | high | +6.00 | +3.51 | -0.59 | -7.54 | 0.40 |
| Equatorial Guinea | intermed. | +11.12 | +10.94 | +10.56 | +9.50 | 0.40 |
| | high | +33.32 | +33.14 | +32.76 | +31.70 | 0.40 |

Table 4: Surplus or deficit supporting capacity (continued)

| | input level | Potential support capacity (millions) excess (+) or deficit (-) on potential rainfed land 1982 (1) | 2000 (2) | 2025 (3) | "plateau" (4) | additional from short transport irrigation (5) |
|---|---|---|---|---|---|---|
| Ethiopia* | intermed. | +34.72 | +9.24 | -44.33 | -97.35 | 5.36 |
| | high | +274.92 | +249.44 | +195.87 | +142.85 | 10.72 |
| Kenya* | intermed. | -6.56 | -27.23 | -71.55 | -78.70 | 4.20 |
| | high | +33.14 | +12.47 | -31.85 | -39.00 | 8.75 |
| Rwanda* | intermed. | -1.55 | -7.00 | -18.60 | -22.44 | 0.16 |
| | high | +3.05 | -2.40 | -14.00 | -17.84 | 0.32 |
| Somalia* | intermed. | -3.25 | -5.21 | -11.33 | -18.13 | 1.08 |
| | high | +1.25 | -0.71 | -6.83 | -13.63 | 2.25 |
| Tanzania | intermed. | +124.63 | +104.61 | +59.94 | +43.74 | 18.40 |
| | high | +481.33 | +461.31 | +416.64 | +400.44 | 36.80 |
| Uganda* | intermed. | +29.90 | +17.19 | -8.37 | -26.04 | 3.28 |
| | high | +140.00 | +127.29 | +101.73 | +84.06 | 6.56 |
| Zaire | intermed. | +1250.89 | +1228.43 | +1176.45 | +1130.84 | 16.00 |
| | high | +2857.59 | +2835.13 | +2783.15 | +2737.54 | 32.00 |
| SOUTHERN AFRICA | | | | | | |
| TOTALS | intermed. | +868.79 | +824.17 | +731.67 | +657.76 | 116.92 |
| | high | +3065.55 | +3020.93 | +2928.43 | +2854.52 | 233.99 |
| Angola | intermed. | +271.35 | +265.57 | +254.33 | +241.80 | 54.60 |
| | high | +923.81 | +918.03 | +906.79 | +894.26 | 107.20 |
| Botswana* | intermed. | +3.90 | +2.90 | +0.70 | -0.24 | 1.20 |
| | high | +45.40 | +44.40 | +42.20 | +41.26 | 2.50 |
| Comoros* | intermed. | +0.12 | -0.22 | -0.58 | -1.00 | |
| | high | +0.62 | +0.28 | -0.08 | -0.50 | |
| Lesotho* | intermed. | -0.01 | -0.85 | -2.66 | -5.60 | 0.08 |
| | high | +1.69 | +0.85 | -0.96 | -3.90 | 0.16 |
| Madagascar | intermed. | +177.60 | +171.27 | +157.16 | +141.82 | 9.60 |
| | high | +544.80 | +538.47 | +524.36 | +509.02 | 19.20 |
| Malawi* | intermed. | +17.65 | +12.55 | +1.03 | -8.78 | 2.32 |
| | high | +50.45 | +43.35 | +33.83 | +24.02 | 4.64 |
| Mauritius* | intermed. | -0.06 | -0.37 | -0.68 | -1.07 | |
| | high | -0.36 | -0.67 | -0.98 | -1.37 | |
| Mozambique | intermed. | +145.37 | +134.64 | +116.72 | +101.42 | 19.20 |
| | high | +523.67 | +512.94 | +495.02 | +479.72 | 38.40 |
| Namibia* | intermed. | +0.99 | -0.32 | -2.23 | -3.44 | 0.60 |
| | high | +30.89 | +29.58 | +27.67 | +26.46 | 1.25 |
| Reunion* | intermed. | -0.04 | -0.18 | -0.32 | -0.75 | |
| | high | +1.06 | +0.92 | +0.78 | +0.35 | |
| Swaziland* | intermed. | +2.77 | +2.32 | +1.42 | +0.36 | 0.08 |
| | high | +5.67 | +5.22 | +4.32 | +3.26 | 0.16 |
| Zambia | intermed. | +209.66 | +204.58 | +192.02 | +185.82 | 28.00 |
| | high | +760.36 | +755.28 | +742.72 | +736.52 | 56.00 |
| Zimbabwe | intermed. | +39.49 | +32.29 | +14.76 | +7.42 | 2.24 |
| | high | +177.49 | +170.29 | +152.76 | +145.42 | 4.48 |

ANNEX 1

**CONSULTATION ON IRRIGATION IN AFRICA**

Lomé, Togo, 21-25 April 1986

Meeting Hall: Salle Concorde, Hotel 2 Février Sofitel

AGENDA

**Sunday 20 April**

| | |
|---|---|
| 20.00 - 21.30 | Registration in Lobby of Hotel 2 Février Sofitel |

**Monday 21 April**

| | |
|---|---|
| 08.00 | Registration (continued) |
| 10.00 - 11.00 | Opening Session |
| | . Address by Director, Land and Water Development Division, FAO |
| | . Address by Assistant Director-General and Regional Representative for Africa of FAO |
| | . Address by H.E. the Minister of Rural Development, Government of Togo |
| 11.30 - 12.30 | Technical Session I: Role of Irrigation in Agricultural Production |
| | . Introductory observations by FAO |
| | . State of Irrigation - Facts and Figures (Doc. I-A) |
| | . Water Resources and Irrigation Potential in Africa (Doc. I-B) |
| 14.30 | . Water Resources (cont.) |
| 16.00 | . Economics of Irrigation Development (Doc. I-C) |

**Tuesday 22 April**

| | |
|---|---|
| 09.00 | . Need for and Justification of Irrigation Development (Doc. I-D) |
| | Technical Session II: Experience Gained |
| 11.00 - 12:00 | . Experience Gained with Irrigation in Africa (Doc. II-A) |
| 14.00 | . Experience Gained (cont.) |
| 16.00 | . Irrigation Development in Southeast Asia - some recent experiences of four countries (Doc. II-B) |

**Wednesday 23 April**

| | |
|---|---|
| | Technical Session III: Policies for Irrigation |
| 09.00 - 12.00 | . Policy Issues in Irrigation Development (Doc. III-A) |
| 14.00 | . Manpower and Training Needs for Irrigation (Doc. III-B (1)) |
| | . Women in Irrigated Agriculture in Africa (Doc. III-B (2)) |
| | . The Role of Non-governmental Organizations in Small-scale Irrigation (Doc. III-B (3)) |

**Thursday 24 April**

| | |
|---|---|
| 09.00 | . Disease Considerations in Water Development for Agriculture (Doc. III- B (4)) |
| | . Land Tenure and Irrigation Development (Doc. III-B (5)) |
| | Technical Session IV: Achieving Irrigation Development |
| 11.00 - 12.00 | . Areas for Action |
| afternoon | . (open) |

**Friday 25 April**

| | |
|---|---|
| 09.00 | . Areas for Action (cont.) |
| | . Action Support Needs |
| 14.00 | Closing Session |
| | . Consultation Report and Conclusions |
| | . Closing address by H.E. the Minister of Rural Infrastructure, Government of Togo |

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**FAO TECHNICAL PAPERS**

**FAO IRRIGATION AND DRAINAGE PAPERS:**

1. Irrigation practice and water management, 1971 (Ar* E* F* S** — E** Rev. 1, 1984)
2. Irrigation canal lining (New edition (1977) available in E, F and S in the FAO Land and Water Development Series)
3. Design criteria for basin irrigation systems, 1971 (E**)
4. Village irrigation programmes — a new approach in water economy, 1971 (E* F*)
5. Automated irrigation, 1971 (E* F* S**)
6. Drainage of heavy soils, 1971 (E** F** S**)
7. Salinity seminar, Baghdad, 1971 (E* F*)
8. Water and the environment, 1971 (E** F* S*)
9. Drainage materials, 1972 (E** F** S**)
10. Integrated farm water management, 1971 (E** F* S*)
11. Planning methodology seminar, Bucharest, 1972 (E** F**)
12. Farm water management seminar, Manila, 1972 (E**)
13. Water-use seminar, Damascus, 1972 (E* F**)
14. Trickle irrigation, 1973 (E** F** S**)
15. Drainage machinery, 1973 (E* F*)
16. Drainage of salty soils, 1973 (E** F** S**)
17. Man's influence on the hydrological cycle, 1973 (E* F** S**)
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